

Field Testing of a New Dredge for the Sea Scallop Fishery

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Executive Summary

In 2006, Coonamessett Farm developed a scallop dredge that was designed to reduce the incidental catch of sea turtles, skates, and flatfish. During the summer of 2007, this new scallop dredge, called the excluder dredge, was tested aboard three different commercial scallop vessels operating under normal fishing practices. This report presents and summarizes the data collected and experience gained during sea trials of the new excluder dredge throughout the 2007 field season.

The first test trip occurred during late August in Closed Area I on George's Bank. This trip compared the excluder dredge to a standard New Bedford dredge. The second trip occurred during the beginning of November in the Elephant Trunk Closed Area of the Mid Atlantic Bight. The third trip also took place in the Elephant Trunk Closed Area, but during the end of November on a different vessel. These last two trips employed two excluder dredges, one with a test feature called "turtle guards" and one without, for the purpose of testing differences in catch. During each trip, a series of additional gear modifications underwent preliminary testing for possible application to the goal of bycatch reduction. This included changes to both the excluder dredge frame and the vessel's chain bag. Trip three also applied a different bag configuration on each dredge for the purpose of testing the effect on catch and for calibrating catch data between vessels.

In total, 275 successful paired tows were conducting using the excluder dredge during the three field trail trips presented in this report. The catch of 174 tows, representing 63% of all tows, were observed and sampled by a scientist on deck. During the first test trip, the excluder dredge was found to reduce yellowtail flounder by 31% and winter flounder by 44%, while increasing scallop catch by 10%. Trip 2 showed that the two excluder dredges had similar catch levels, with the exception of the dredge with turtle guards landing 12% more skate than the dredge without turtle guards. The results from trip 3 proved that the configuration of the chain bag used on the excluder dredge affects both the catches levels and ease of use by fishers. This suggests that a standard bag configuration needs to be developed specifically for use on the excluder dredge. In addition, gear modifications to the chain bag showed promise in further reducing bycatch levels, although more extensive testing and refinements need to be completed.

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Introduction

During 2006, Coonamessett Farm completed a Scallop RSA study that designed and conducted preliminary testing of three new scallop dredge frame designs. The purpose of developing a new dredge frame was to: make it lighter, structurally stronger, able to capture scallops at least as efficiently as a standard New Bedford dredge, and most importantly, reduce the capture and retention of sea turtles, skates and flatfish species. In addition, the new dredge had to be constructed of materials readily available to the scallop fishing industry, required no additional costs or modifications to standard fishing operations, and was voluntarily acceptable by the fishers. The 2006 study successfully met all these goals and resulted with a final dredge designed called the excluder dredge. This 2007 Scallop RSA study was a continuation the development of the new excluder dredge design involving extensive field testing, minor refinements to the final design, and exploratory testing of other possible bycatch reduction gear modifications.

The new excluder dredge tested in this study is a dramatic design change when compared to the standard New Bedford dredge currently in use by the entire scallop dredge fishery. The cutting bar is moved forward of the depressor plate and set at a 45 degree angle so that instead of confronting a vertical structure, a groundfish or skate, encounters a sloping structure. This design concept utilizes both the dredge frame's hydrodynamic characteristics and fish avoidance behavior to exclude non-targeted species from the dredge while retaining the target species. By lowering the dredge profile, non-target animals (including sea turtles) can either be guided over the dredge via hydrodynamic forces or allowed the opportunity to swim over the dredge frame, thus never being overtaken by the dredge and entering the bag. Meanwhile, scallops are captured and retained in a manner similar to that utilized by the traditional New Bedford dredge.

The excluder dredge also has design characteristics developed specifically to reduce injury to sea turtles. The new excluder dredge does not have the interior bale bars of the standard New Bedford dredge. These bars could prevent a turtle overtaken by the bail from escaping upwards or even to be caught between the bars. Removing the bale bars removed an obstruction thus allowing a turtle to rise up in front of the cutting bar to be "excluded". The purpose of these bail bars on the old dredge was to increase the structure rigidity when towing in areas with large rocks and boulders. To maintain structural strength on the excluder dredge, the outside bail bars were doubled and center bar retained. To further strengthen the frame and reduce the risk of turtles getting caught on the frame, the strut spacing was reduced from 12 to 9 inches. (These smaller spaces may also assist in reducing the amount of fish species entering through the frame.) In addition, turtles could be caught in the

corners where the bail is attached to the dredge frame. This was addressed by adding 15” straight extensions on each side connecting the bale to the frame. A detailed description of the excluder dredge development, design, and preliminary testing is available in 2005 RSA Final Report NA05NMF4541293.

The modifications to the dredge frame were also designed to not require changes relative to the handling and operation of the dredge. This was accomplished by maintaining the dredge frame length and width. This is a very important criterion as the vessels are rigged to handle dredges of a particular length and width. It also allows the new dredge design to meet the gear specifications required in the current fishing regulation.

Preliminary testing of the excluder dredge design tested in this study occurred during four trips in the Hudson Canyon Closed Area during the summer of 2006. Those tests found that the new dredge design had comparable catch efficiency for scallops relative to the standard New Bedford dredge design while significantly reducing bycatch of several non-targeted species. However, due to the limited diversity and low levels of bycatch in the area fished, definitive results were not able to be substantiated. This 2007 RSA study augmented these previous test trips by allowing testing to occur on three different vessels under a variety of fishing conditions. The 2007 trips allowed additional modifications to be tested and a design finalized.

Methodology

The excluder dredges used during this study were constructed by Dockside Repair, Inc in New Bedford. Dockside Repair is a well respected dredge builder and it is hoped that the excluder dredge design will be utilized by this shop and others. Each dredge was build according to the same general design features, concepts, and materials. A few minor differences in construction were noted between dredges and are documented in Appendix # 34-35.

RSA compensation trips were used for all of the 2007 field trials. To keep data collection consistent, the same scientist was onboard each of the three trip. During the first two trips there was an additional scientist onboard to assist with catch sampling and data recording. A target of 60 sampled tows was set for each trip. At a minimum, all fish specimens and bushel baskets of scallops were counted for each dredge to be considered a sampled tow. Tows where there was a gear problem (ie hang up or flipped dredge) where not sampled or included in the data set. Each scientist was responsible for tallying the fish count on one side throughout the trip. Fish were measured by the same scientist all trip, with the second recording data. Fish lengths were collected as time permitted and were usually completely sampled every tow, with the exception of little skate which was sub-sampled. Fish length frequencies were recorded in 1.0 cm increments. During every other tow, a bushel basket of scallops was collected randomly by the scientist from each dredge’s catch. This sub-sample of scallops was measured for shell height in 5 mm increments.

Three different limited access vessels were used during these trips. The crews were instructed to perform normal fishing operations. Towing variables such as speed, length, scope, and direction were left to the

discretion of the captain or mate. This allowed not only diverse testing conditions, but also a more realistic testing of the new dredge under real commercial fishing operations. Watch hours used by the scientific party and crew were set by the captain. The crew continued with the recording of bridge log data and scallop bushel counts for every tow when the scientific party was off watch. Tows where the scientific party were off watch were considered unobserved tows and grouped separately.

The crew's preferred bag configuration was used during each trip with the exception of the last trip which two different specifications were used. An ESA permit was obtained to allow for the bags to be rigged without turtle chains. Fishing without turtle chains allow analysis to be conducted regarding the ability of the new dredge design to reduce the number of incidental takes of sea turtles. For this purpose, the gears used during the last two trips were set up using a minimal amount of rock and tickler chains (one center rock chain and one tickler chain).

All data were entered into Excel spreadsheets after the trip had landed. All data collected and data summaries for each trip are available in the appendix. Data was analyzed to determine differences in catch rates between dredges of target and non-target species and any differences in size selectivity of the target and non-target catch. A paired t-test at the $\alpha=0.05$ level was used to test for significance in catches between the standard control and excluder dredge.

Field Operations

Three commercial scallop trips were used during the late summer/fall of 2007 to test the excluder dredge at sea. A different fishing vessel was used during each trip. These vessels were the Diligence, Celtic, and Westport. One trip, Diligence-2007-2, was made to Georges Bank in Closed Area I during the summer months. The remaining two trips, Westport-2007-2 and Celtic-2007-3, were completed in the Mid Atlantic Bight within the Elephant Trunk Closed Area both during the fall. A total of 275 quantifiable paired tows were conducted during these trips. A scientist onboard sampled the catch of 174 (63%) of the successful tows.

Five important tests were successfully conducted during the three 2007 field trials of the new excluder test design. These test included:

- 1) A performance and catch comparison of excluder dredge to standard New Bedford dredge on hard bottom
- 2) Field trials of a new turtle guard design
- 3) A comparison of excluder dredges with turtle guards and without
- 4) A comparison of turtle dredges with frame chains and without
- 5) A comparison of different bag configurations used on the excluder dredge

In addition to these tests, several preliminary gear experiments were conducted to explore modification concepts that could further reduce the retention of non-target species. The ideas explored included: drop chains on the cutting bar as well the placement of escape vents in different locations of the bag. A break down of what

tests were conducted during each trip is provided below in Table 1. The exploratory modifications made are listed and described in each individual trip summary, which follow.

Table 1. Summary of all at field trial trips included in this report

Trip ID	Vessel Name	Observer	Date Sailed	Date Landed	Area	Trip Type	Tows	Observed Tows	Tested	Control Dredge	Turtle Chains
Diligence-2007-2	Diligence	Ron/Matt	8/20/2007	8/27/2007	CA I	RSA Collection	93	54	Excluder Dredge with large turtle guards	Standard 15' New Bedford	No
Celtic-2007-6	Celtic	Matt/Patrick	11/5/2007	11/13/2007	Elephant Trunk	RSA Collection	82	60	Excluder Dredge w/ turtle guards Excluder Dredge w/ turtle guards & with	Excluder Dredge without turtle guards Excluder Dredge without turtle guards &	No
Westport-2007-2	Westport	Matt	11/20/2007	11/29/2007	Elephant Trunk	RSA Collection	100	60	Westport gear configuration	with Celtic's gear configuration	No

Diligence-2007-2

The trip Diligence-2007-2 sailed from New Bedford on 8/20/2007 for an RSA collection trip in the Closed Area I under LOA 410249. The scientists onboard were Ron Smolowitz and Matt Weeks. A total of 100 tows were conducted during this trip. Of those tows, 93 were deemed both successful and the catch quantifiable (ie no deck loading, flipped dredges, or hang-ups). The scientist onboard sampled 54 tows, representing 58% of the total successful tows. The Diligence stopped fishing on 8/26/2007 and landed in New Bedford on 8/27/2007 for a total of 8 days at sea.

The primary research interest for this trip was to continue testing of the turtle excluder dredge aboard a commercial scallop fishing vessel operating under normal fishing conditions. A turtle excluder dredge was fished alongside the vessel's standard New Bedford dredge. The New Bedford dredge served as the control dredge for this trip. The crew deployed, fished, and retrieved both dredges in a paired tow configuration for the entire trip. The vessel's chain bags were used on both dredges. No turtle chains were used, although a large number of rock and tickler chain were used as is typical for this vessel. A photograph of the excluder dredge and fishing vessel's chain bag is given below in Figure 1.



Figure 1. Photograph of the excluder dredge and chain bag used during Diligence-2007-2

The bags of each frame dredge were exchanged after tow 35. The sides that each dredge fished were switched so that the excluder dredge, which had been fishing on the starboard side, was now fishing on the port.

The dredges remained in this configuration for the rest of the trip. The reason for doing the switch was to examine if there was any side effect or difference in how the bags fished on the different frames.

Two exploratory gear modifications were tested during the course of this trip. The first was the addition of 6 “drop chains” to the turtle excluder dredge, which occurred after tow 63 and remained on for the rest of the trip. The drop chains consisted of ½” links attached from the cutting bar to the first tickler. Enough links were used so that there was slack in the chain when attached. The second modification tested was the addition of “escape windows” in the excluder dredge’s twine top. The escape vents were made by cutting 3 holes in aft part of the twine top. This modification was made after tow 81 and remained on the turtle excluder dredge for the rest of the trip. A summary of exploratory modifications tested during this trip is given below in Table 2.

Table 2. Summary of exploratory gear modifications made during trip Diligence-2007-2

#	Modification	Dredge	Date Start	Tows	Tow Count	Obs Count	Description
1	No change	-	8/21/2008	1 thru 35	35	20	excluder dredge=starboard, control dredge=port
2	Switched Gear	both	8/22/2008	36 thru 63	28	13	excluder=port, control=starb, bags remained on same sides
3	Drop Chains	excluder	8/24/2008	64 thru 81	18	11	added 6 chains linking cutting bar and 1st ticker chain
4	Escape Vents	excluder	8/25/2008	82 thru 100	19	10	cut 3 holes in aft section of the twine top

The scientist conducted fish counts and scallop bushel counts on all observed tows. Fish counts for each observed tow are provided in the Appendices. A total of 10 different bycatch species were observed during the trip. All fish landed during observed tows were measured with the exception of little skate, which were counted. Length data for select species is provided in the Appendices. Retained scallops were collected into bushel baskets by the crew and the number for each dredge recorded by the captain or mate. Bushel counts were conducted for every tow, even when the scientist was off watch. The scientists maintained a watch during daylight hours from 05:30 until 18:30. Bridge data were recorded by the captain and mate for each tow throughout the trip. All data were edited and entered by the scientist into an Excel spreadsheet once ashore.

The tow times ranged from 15 minutes to 64 minutes, with an average of 47 minute tow duration for the entire trip. Tow speed ranged from 4.0 to 5.1 knots, with an average of 4.5 knots for the trip. Fishing depth ranged from 31 to 40 fathoms, with an average of 35 fathoms for the entire trip. Scallop catch sizes ranged from 3 to 37 bushels per a side. The excluder dredge (with modifications made at different points during the trip) averaged 15 bushels per tow while the control dredge averaged 14 bushels per tow. Detailed tow by tow bridge log data recorded during this trip is provided in the Appendices.

Cletic-2007-6

The trip Celtic-2007-6 sailed from New Bedford on 11/5/2007 for an RSA collection trip in the Elephant Trunk Closed Area under LOA 410146. A total of 20,740 lbs of scallops were allocated for this trip. The scientist onboard was Matt Weeks and Tim Winchenbach assisted as observer. Paul D. was captain for this trip

with Tim Quinn as mate. The crew included Anthony, Joe, John, Pat, and Jim. All crew members were very cooperative with the research done during this trip.

A total of 109 tows were conducted during this trip. Of those tows, 82 were deemed both successful and the catch quantifiable (ie no deck loading). The scientist onboard sampled 60 tows, representing 73% of the total successful tows. The Celtic stopped fishing on 11/12/2007 and returned to New Bedford on 11/13/2007 for a total of 9 days at sea. The entire catch was sold to Eastern Fisheries.

The primary research goal of this trip was to test for any affect of turtle guards on scallop catch and fish bycatch. Two turtle excluder dredge frames were fished side by side for the duration of this trip. The two dredge frames were basically identical except for the turtle guards on one dredge's cutting bar. The turtle guards consisted of 1-inch round stock hardened steel placed flush to the cutting bar and overlapping and extending from each strut on the frame. These turtle guards differed from previous versions in that they were flush to the cutting bar instead of extending out as they were during the trip Diligence-2007-2. The dredge with these turtle guards was designated dredge A and was fished on the port side throughout the trip. Dredge B was the same dredge design without turtle guards and was fished on the starboard side throughout the trip. Some minor differences in how the dredges were constructed were noted and are available in the appendices. Photos of both dredge frames used during this trip are below in Figures 2 thru 5.

Dredge A = turtle dredge WITH turtle guards (port side)

Dredge B = turtle dredge WITHOUT turtle guards (starboard side)



Figure 2. Photograph of Dredge B's cutting bar



Figure 3. Photograph of Dredge B



Figure 4. Photograph of Dredge A’s cutting bar and turtle guards

Figure 5. Photograph of Dredge A

A secondary interest was to collect baseline catch data for future analysis regarding the effect of different dredge bag configurations used new turtle excluder dredge. The dredge bags used on each dredge were set up identically in a configuration regularly used by the F/V Celtic. A summary of the Celtic’s preferred bag configuration is available in the appendices. Both bags used during this trip were made of new gear. This included new twine tops that measured 11 inches before use and hung with a mesh ratio of 2:1. No turtle chains were used during this trip as allowed by the ESA permit. A chain arrangement of one rock chain and one tickler chain were used on both dredges. A photograph of the chain bag used is provided below in Figure 6.



Figure 6. Photograph of Dredge A and chain bag used during Celtic-2007-6

One other minor gear modification was tested during the end of the trip. The chains (frame chains) that block the “window” between the pressure plate, cutting bar, and struts were removed from dredge B for the last 10 tows. The frame chains were left on dredge B during this test. The purpose was to test if there was an observable effect of the frame chains on scallop catch and/or fish bycatch. A summary of all the exploratory modifications tested during this trip is given below in Table # 3.

Table 3. Summary of exploratory gear modifications made during trip Celtic-2007-6

#	Modification	Dredge	Date Start	Tows	Tow Count	Obs Count	Description
1	No change	-	11/6/2008	1 thru 95	95	48	excluder dredge with turtle guards=A, excluder dredge without guards=B
2	Removed Frame Chains	B	11/11/2008	96 thru 109	14	12	cut all chains between cutting bar, struts, and pressure plate

The scientist conducted fish counts and scallop bushel counts on all observed tows. Fish counts for each observed tow are provided in the Appendices. A total of 10 different bycatch species were observed during the

trip. Length data for select species is provided in the Appendices. A total of 48 bushel baskets of scallop were randomly selected and shell heights taken from both dredges. Species that were sampled for length frequency included: 715 little skates, 168 clearnose skate, and 83 fluke. All length data collected is provided in the Appendices. Additional data for other species is available if requested.

Retained scallops were collected into bushel baskets by the crew and the number for each dredge recorded by the captain or mate. Bushel counts were conducted for every tow, even when the scientist was off watch. The scientists primarily observed tows conducted between 05:00 and 16:00, with around the clock coverage later in the trip. Bridge data were recorded by the captain and mate for each tow throughout the trip. All data were edited and entered by the scientist into an Excel spreadsheet once ashore. A detailed day by day log of the entire trip is available in the appendices.

Scallop catch sizes ranged from 2 to 36 bushels per side. Both dredges averaged 13 bushels per a tow. The tow times ranged from 15 minutes to 78 minutes, with an average of 46 minute tow duration for the entire trip. Tow speed ranged from 4.0 to 4.8 knots, with an average of 4.3 knots for the trip. Fishing depth ranged from 20 to 28 fathoms, with an average of 22 fathoms for the entire trip. Scallop catch sizes ranged from 2 to 36 bushels per a side. Both dredges averaged 13 bushels per a tow. A total of 10 different bycatch species were observed during the trip. Detailed tow by tow bridge log data recorded during this trip is provided in the Appendices.

Westport-2007-2

The trip Westport-2007-2 sailed from New Bedford on 11/20/2007 for an RSA collection trip in the Elephant Trunk Closed Area under LOA 410249. A total of 20,739 lbs of scallops were allocated for this trip. The scientist onboard was Matt Weeks. Eddy Welch was captain for this trip with Nate as mate. The crew included Foggy, Shane, Shane, Jim, and Tom. All crew members were very cooperative with the research done during this trip.

A total of 100 tows were conducted during this trip. Of those tows, 96 were deemed both successful and the catch quantifiable (ie no deck loading or hang-ups). The scientist onboard sampled 62 tows, representing 65% of the total successful tows. The Westport stopped fishing on 11/28/2007 and landed in New Bedford on 11/29/2007 for a total of 10 days at sea. The entire catch was sold at the New Bedford Seafood Auction.

The primary research interest for this trip was to examine any effect caused by different chain bag configurations being used on the new excluder dredge. Two turtle excluder dredge frames were fished side by side for the duration of this trip. Both of these dredge frames were used previously on Celtic-2007-6 (figures # 7-9). The two dredge frames were basically identical except for the turtle guards on one dredge's cutting bar. As during the previous trip on the Celtic, the turtle guards consisted of 1-inch round stock hardened steel placed flush to the cutting bar and overlapping and extending from each strut on the frame. The dredge with turtle

guards was designated dredge A and fished on the starboard side for the entire trip. Dredge B was the same dredge design without turtle guards and was fished on the port side throughout the trip. Dredge B had the frame chain replaced, since they had been removed during the previous trip on the Celtic. These replacement chains had slightly more slack in them relative to the frame chains on dredge A.

A secondary interest was to collect catch data for future analysis regarding the effect of different dredge bag configurations used new turtle excluder dredge. For this trip two different dredge bags were used for comparison purposes. One dredge (dredge B) bags was set up in a configuration identical to that used by the F/V Celtic during Celtic-2007-6. The other dredge (dredge A) employed a bag set up preferred by the F/V Westport. Both bags used during this trip were made of old gear that had been used by the Westport for the entire fishing season. Dredge B had a new twine top installed, while dredge A used an old twine top used on previous trips. No turtle chains were used during this trip as allowed by the ESA permit. A chain arrangement of one rock chain and one tickler chain were used on both dredges. A photograph of the each chain bags used is provided below in Figures 7 and 8.

Dredge A = turtle excluder dredge frame WITH turtle guards; F/V Westport's bag configuration.

Dredge B = turtle excluder dredge frame WITHOUT turtle guards; F/V Celtic's bag configuration.



Figure 7. Photograph of Dredge A and chain bag used during Westport-2007-2



Figure 8. Photograph of Dredge B and chain bag used during Westport-2007-2

Two additional gear modifications were tested during the course of this trip. All gear modifications were made to dredge B. The first modification occurred after tow 72 with the frame chains being removed from dredge B, as had occurred during Celtic-2007-6. The frame chains were not reapplied after removal. A photograph showing dredge B after the frame chains being removed is provide in Figure 9 below.



Figure 9. Photograph of frame chains being cut off dredge B during Westport-2007-2

The second gear modification was the opening of large “windows” in the front corners of dredge B’s twine top. This was done by unraveling the twine top three rings across and three rings deep in each forward corner. This opened up approximately 10 meshes in the twine tip. The loose meshes were tied back onto the twine top so that it could be rebuilt after testing. This modification was tested during the last 5 tows, 95-100. A photograph of the windows is given in Figures 10 and 11 below. A summary of all exploratory modifications tested during this trip is provided in Table 4.

Table 4. Summary of exploratory gear modifications made during trip Westport-2007-2

#	Modification	Dredge	Date Start	Tows	Tow Count	Obs Count	Description
1	No change	-	11/21/2008	1 thru 72	67	44	A=excluder dredge with turtle guards and Celtic's gear, B=excluder dredge without guards and with Westport gear
2	Removed Frame Chains	B	11/26/2008	73 thru 94	21	13	cut all chains between cutting bar, struts, & pressure plate
3	Removed Frame Chains	B	11/28/2008	95 thru	6	5	put holes in forward corners of twine top



Figure 10. Photograph window created in dredge B’s twine top during Westport-2007-2



Figure 11. Photograph of dredge B with corner windows

The scientist conducted fish counts and scallop bushel counts on all observed tows. Fish counts for each observed tow are provided in the Appendices. A total of 9 different bycatch species were observed during the trip. Fish lengths and scallop shell heights were collected after every tow. Length data for select species is provided in the Appendices. A total of 54 bushel baskets of scallop were randomly selected from both dredges and shell heights frequencies collected to the nearest millimeter. Counts of fish species that were sampled for length frequency included: 2,034 little skates, 190 clearnose skate, 310 fluke, and 143 monkfish. Length data for select species is provided in the Appendices. Additional length data for other species is available if requested.

All retained scallops were collected into bushel baskets by the crew and the number for each dredge recorded by the captain or mate. Bushel counts were conducted for every tow, even when the scientist was off watch. The scientists observed tows during the captain's watch, which occurred around the clock. Bridge data were recorded by the captain and mate for each tow throughout the trip. All data were edited and entered by the scientist into an Excel spreadsheet once ashore. A detailed day by day log of the entire trip is available in the appendices.

The same area was fished as during the previous trip Celtic-2007-6. The tow times ranged from 28 minutes 90 minutes, with an average of 60 minute tow duration for the entire trip. The crew occasionally had trouble flaring both dredges at the same time, so deployment time was not exactly the same for some tows. Tow speed ranged from 3.8 to 4.5 knots, with an average of 4.1 knots for the trip. Fishing depth ranged from 24 to 39 fathoms, with an average of 27 fathoms for the entire trip. Scallop catch sizes ranged from 4 to 36 bushels per a side. Both dredges averaged 15 bushels per tow. Detailed tow by tow bridge log data recorded during this trip is provided in the Appendices.

Results

Data for each trip were compiled and summarized by dredge and species caught. These summaries can be found in appendix # 1 thru # 6. A length frequency data collected for some bycatch species is provided in appendix # 7 thru # 20. A brief discussion of quantitative and qualitative results of each trip follows.

Diligence-2007-2

The first 35 tows were completed without modifications to either dredge. A total of 20 of the 35 tows were sampled. During these tows, the excluder dredge caught 14% more scallops than the standard dredge while reducing skate catch by 12%, yellowtail flounder by 24%, and winter flounder by 35%. No bycatch levels were significantly increased for any species in the excluder dredge. Bycatch levels that were found to be significantly different ($p < 0.05$) in the excluder dredge are listed in Table 5, along with scallop catch statistics for these tows. A complete listing of results for all species landed is provided in Appendix # 21.

Table 5. Summary of species caught during trip Diligence-2007-2 tows 1-35 whose total count was significantly ($p < 0.05$) different in the excluder dredge relative to a standard New Bedford dredge before significant modifications were made

Tows 1-35: Excluder Dredge on Starboard Side										
Species	Scallop Bushels (all good tows)		Scallop Bushels (obs tows)		Skates		Yellowtail Flid.		Winter Flid.	
Dredge	Excluder	Standard	Excluder	Standard	Excluder	Standard	Excluder	Standard	Excluder	Control
Total Count	573.7	502.5	331.0	290.5	1030	1170	108	142	77	118
% Difference in Count	14.2%		13.9%		-12.0%		-23.9%		-34.7%	
Fish Count/Scallop Bushel Catch Ratio					3.11	4.03	0.33	0.49	0.23	0.41
% Difference in Catch Ratio					-23%		-33%		-43%	
Mean	16.4	14.4	16.6	14.5	52	59	5	7	4	6
Standard Error	1.1	0.7	1.2	0.8	8.7	10.0	1.2	1.6	0.6	0.9
Median	16.0	15.0	16.8	15.3	32	33	4	5	3	5.5
Mode	13.0	16.0	11.0	16.0	119	17	4	3	3	3
Standard Deviation	6.4	4.4	5.2	3.6	39.0	44.9	5.2	7.3	2.8	4.2
Sample Variance	41.1	19.1	26.7	12.8	1522.1	2012.2	27.5	52.8	7.7	17.8
Kurtosis	1.8	0.1	-0.5	-0.6	-0.57	-0.66	8.25	8.60	0.97	11.97
Skewness	0.87	-0.06	0.08	-0.53	0.97	0.94	2.61	2.77	1.12	3.12
Range	31.0	20.0	18.5	13.0	111	122	23	32	11	20
Minimum	6.0	5	7.5	7	15	17	1	1	0	2
Maximum	37.0	25	26.0	20	126	139	24	33	11	22
Confidence Level(95.0%)	2.20	1.50	2.42	1.67	18.26	20.99	2.45	3.40	1.30	1.97
Observations	35	35	20	20	20	20	20	20	20	20
Pearson Correlation	0.92		0.94		0.98		0.92		0.28	
Hypothesized Mean Difference	0		0		0		0		0	
df	34		19		19		19		19	

After tow 35 the sides and bags were switched. The excluder dredge, which had been fishing on the starboard side, was moved to the port and fished with the bag that had been attached to the standard dredge. In this arrangement the excluder dredge did not catch a significantly different amount of scallops relative to the standard dredge. Winter flounder continued to be caught at a significantly reduced rate in the excluder dredge. A total of 13 tows were conducted before additional modifications were made. Bycatch levels that were found to be significantly different ($p < 0.05$) in the excluder dredge are listed in Table 6, along with scallop catch statistics for these tows. A complete listing of results for all species landed with the gear in this configuration is provided in Appendix # 22.

Table 6. Summary of scallop and bycatch species landed during trip Diligence-2007-2 tows 36-61 whose total count was significantly ($p < 0.05$) different in the excluder dredge relative to a standard New Bedford dredge after the sides and chain bags were switched but before significant modifications were made

Tows 36-61 : Excluder Dredge on Port Side with Different Bag								
Species	Scallop Bushels (all good tows)		Scallop Bushels (obs tows)		Winter Fld.		Fourspot Fld.	
Dredge	Excluder	Standard	Excluder	Standard	Excluder	Standard	Excluder	Standard
Total Count	347.5	340.5	182.0	177.5	64	102	46	65
% Difference in Count	2.1%		2.5%		-37.3%		-29.2%	
Fish Count/Scallop Bushel Catch Ratio					0.19	0.35	0.14	0.22
% Difference in Catch Ratio					-45%		-38%	
Mean	14.5	14.2	14.0	13.7	5	8	4	5
Standard Error	0.8	0.8	1.1	1.0	1.0	1.6	0.7	0.9
Median	14.3	13.0	14.0	13.0	4	7	3	4
Mode	15.0	12.0	18.5	13.0	3	4	3	4
Standard Deviation	3.7	4.1	4.0	3.6	3.6	5.6	2.7	3.2
Sample Variance	14.0	16.5	15.7	13.1	13.2	31.5	7.3	10.0
Kurtosis	0.5	-0.6	0.0	-0.8	-0.55	0.14	0.18	5.50
Skewness	0.33	0.37	-0.09	0.14	0.59	0.64	0.91	2.13
Range	16.0	15.5	14.0	11.5	12	19	9	12
Minimum	7.0	7.5	7.0	7.5	0	1	0	2
Maximum	23.0	23	21.0	19	12	20	9	14
Confidence Level(95.0%)	1.58	1.71	2.39	2.18	2.20	3.39	1.63	1.91
Observations	24	24	13	13	13	13	13	13
Pearson Correlation	0.80		0.88		0.78		0.78	
Hypothesized Mean Difference	0		0		0		0	
df	23		12		12		12	
α	0.05		0.05		0.05			
t Stat	0.57		0.65		-2.95		-2.66	
P(T<=t) one-tail	0.287		0.264		0.006		0.010	
t Critical one-tail	1.71		1.78		1.78		1.78	
P(T<=t) two-tail	0.574		0.528		0.012		0.021	
t Critical two-tail	2.07		2.18		2.18		2.18	

A total of 59 tows were completed and 33 sampled before significant modifications were applied. During the first 59 tows, the excluder dredge was found to have caught 10% more scallops while reducing the catch rate of yellowtail flounder by 21%, winter flounder by 36%, and sand dab by 73%. Counts of other

bycatch species were not found to be statistically different. No bycatch levels were significantly increased for any species in the excluder dredge. Bycatch levels that were found to be significantly different ($p < 0.05$) in the excluder dredge are listed in Table 7, along with scallop catch statistics for these tows. A complete listing of results for all species landed is provided in Appendix # 23.

Table 7. Summary of species caught during trip Diligence-2007-2 tows 1-61 whose total count was significantly ($p < 0.05$) different in the excluder dredge relative to a standard New Bedford dredge before significant modifications were made

Tows 1-61 : Experimental Dredge Before Modifications								
Species	Scallop Bushels (all good tows)		Scallop Bushels (obs tows)		Yellowtail Fld.		Winter Fld.	
	Excluder	Standard	Excluder	Standard	Excluder	Standard	Excluder	Standard
Dredge								
Total Count	921.2	843.0	513.0	468.0	146	185	141	220
% Difference in Count	9.3%		9.6%		-21.1%		-35.9%	
Fish Count/Scallop Bushel Catch Ratio					0.44	0.64	0.43	0.76
% Difference in Catch Ratio					-31%		-44%	
Mean	15.6	14.3	15.5	14.2	4	6	4	7
Standard Error	0.7	0.5	0.8	0.6	0.8	1.1	0.5	0.8
Median	15.0	14.0	15.5	14.5	4	4	3	6
Mode	12.0	13.0	21.0	16.0	2	4	3	7
Standard Deviation	5.5	4.2	4.8	3.6	4.4	6.1	3.1	4.8
Sample Variance	30.5	17.8	23.3	12.7	19.3	37.1	9.8	23.3
Kurtosis	2.7	-0.2	-0.2	-0.9	12.12	12.95	0.06	3.27
Skewness	1.04	0.09	0.22	-0.25	3.04	3.25	0.89	1.69
Range	31.0	20.0	19.0	13.0	24	33	12	21
Minimum	6.0	5	7.0	7	0	0	0	1
Maximum	37.0	25	26.0	20	24	33	12	22
Confidence Level(95.0%)	1.44	1.10	1.71	1.26	1.56	2.16	1.11	1.71
Observations	59	59	33	33	33	33	33	33
Pearson Correlation	0.86		0.91		0.88		0.56	
Hypothesized Mean Difference	0		0		0		0	
df	58		32		32		32	
α	0.05		0.05		0.05		0.05	
t Stat	3.55		3.55		-2.23		-3.42	
P(T<=t) one-tail	0.000		0.001		0.016		0.001	
t Critical one-tail	1.67		1.69		1.69		1.69	
P(T<=t) two-tail	0.001		0.001		0.033		0.002	
t Critical two-tail	2.00		2.04		2.04		2.04	

The first major modification, drop chains, was added after tow 63. The results from these 18 tows were similar to the previous 59. The excluder dredge caught 10% more scallops while reducing bycatch at a similar level as before. One significant difference found during tows with the drop chains was a reduction of fourspot flounder in the excluder dredge by 35%. No bycatch levels were significantly increased for any species in the excluder dredge. Bycatch levels that were found to be significantly different ($p < 0.05$) in the excluder dredge are listed in Table # 8, along with scallop catch statistics for these tows. A complete listing of results for all species landed is provided in Appendix # 24.

Table 8. Summary of species caught during trip Diligence-2007-2 tows 63-81 whose total count was significantly different in the excluder dredge relative to a standard New Bedford dredge after the drop chains were added to the excluder dredge

Tows 63-81: Drop Chains on Experimental Dredge						
Species	Scallop Bushels (all good tows)		Scallop Bushels (obs tows)		Fourspot Fld.	
	Excluder	Standard	Excluder	Standard	Excluder	Standard
Dredge						
Total Count	263.0	239.5	146.0	138.0	26	40
% Difference in Count	9.8%		5.8%		-35.0%	
Fish Count/Scallop Bushel Catch Ratio					0.08	0.14
% Difference in Catch Ratio					-43%	
Mean	14.6	13.3	13.3	12.5	2	4
Standard Error	0.8	0.7	0.9	1.0	0.4	0.4
Median	15.0	13.8	13.0	13.0	2	3
Mode	15.0	10.0	15.0	13.0	1	3
Standard Deviation	3.6	3.0	2.8	3.4	1.4	1.3
Sample Variance	12.6	9.2	8.0	11.4	1.9	1.7
Kurtosis	-0.6	-0.1	-0.5	-0.1	-0.44	-0.61
Skewness	0.21	-0.47	-0.16	0.03	0.64	0.49
Range	12.0	12.0	9.0	12.0	4	4
Minimum	9.0	6.5	9.0	6.5	1	2
Maximum	21.0	18.5	18.0	18.5	5	6
Confidence Level(95.0%)	1.77	1.51	1.90	2.27	0.91	0.86
Observations	18	18	11	11	11	11
Pearson Correlation	0.79		0.89		0.43	
Hypothesized Mean Difference	0		0		0	
df	17		10		10	
α	0.05		0.05			
t Stat	2.54		1.54		-2.97	
P(T<=t) one-tail	0.010		0.078		0.007	
t Critical one-tail	1.74		1.81		1.81	
P(T<=t) two-tail	0.021		0.156		0.014	

A second gear modification was tested during the last 16 tows. During these final tows, three large holes were cut in the aft section of the excluder dredge's twine top to serve as "windows". Ten tows were sampled while the excluder dredge's twine top had these holes. This resulted in the excluder dredge catching approximately the same amount of scallops as the standard dredge, thus a 10% reduction from the previous 82 tows. The amount of trash (i.e. bottom material such as shells, rock, sponge, sand dollars) was reduced by 35% when compared to the standard dredge. Winter flounder were reduced by 44% and summer flounder by 90% relative to the standard dredge. Counts of all other fish species landed during these tows were reduced by a large amount, although not enough tows were sampled to prove a difference statistically. No bycatch levels were significantly increased for any species in the excluder dredge. Bycatch levels that were found to be significantly different ($p < 0.05$) in the excluder dredge are listed in Table 9, along with scallop catch statistics for these tows. A complete listing of results for all species landed is provided in Appendix # 25.

Table 9. Summary of scallop catch and species caught during trip Diligence-2007-2 tows 82-100 whose total count was significantly different ($p < 0.05$) in the excluder dredge relative to a standard New Bedford dredge after the windows were cut in the excluder dredge's twine top

Tows 82-100: Holes Cut in Twine Top on Experimental Dredge										
Species	Scallop Bushels (all good tows)		Iop Bushels (obs tows)		Trash Bushels		Winter Flid.		Summer Flid.	
	Excluder	Standard	Excluder	Standard	Excluder	Standard	Excluder	Standard	Excluder	Standard
Total Count	222.0	216.0	120.0	123.5	21.5	33.0	33	59	2	17
% Difference in Count	2.8%		-2.8%		-34.8%		-44.1%		-88.2%	
Fish Count/Scallop Bushel Catch Ratio					0.06	0.11	0.10	0.20	0.01	0.06
% Difference in Catch Ratio					-43%		-51%		-90%	
Mean	13.9	13.5	12.0	12.4	2.2	3.3	3	6	0	2
Standard Error	1.3	1.2	1.6	1.6	0.3	0.3	1.1	1.8	0.2	0.7
Median	14.0	13.3	13.0	12.8	2.0	3.0	2.5	5	0	1
Mode	14.0	12.0	#N/A	#N/A	2.0	3.0	3	6	0	0
Standard Deviation	5.3	4.9	5.0	5.0	1.0	0.9	3.4	5.8	0.6	2.3
Sample Variance	27.9	23.9	25.3	25.4	1.0	0.9	11.6	33.2	0.4	5.1
Kurtosis	0.2	0.9	-0.7	0.9	0.4	-0.3	2.14	6.17	10.00	2.74
Skewness	-0.20	0.15	-0.42	-0.17	0.21	0.23	1.48	2.31	3.16	1.69
Range	21.0	20.0	15.5	18.5	3.5	3.0	11	20	2	7
Minimum	3.0	3.5	3.0	3	0.5	2	0	1	0	0
Maximum	24.0	23.5	18.5	21.5	4.0	5	11	21	2	7
Confidence Level (95.0%)	2.81	2.61	3.60	3.61	0.72	0.68	2.43	4.12	0.45	1.62
Observations	16	16	10	10	10	10	10	10	10	10
Pearson Correlation	0.92		0.92		0.59		0.84		0.82	
Hypothesized Mean Difference	0		0		0		0		0	
df	15		9		9		9		9	
α	0.05		0.05		0.05		0.05		0.05	
t Stat	0.73		-0.55		-4.12		-2.39		-2.67	
P(T<=t) one-tail	0.239		0.297		0.001		0.020		0.013	
t Critical one-tail	1.75		1.83		1.83		1.83		1.83	
P(T<=t) two-tail	0.478		0.594		0.003		0.040		0.026	
t Critical two-tail	2.13		2.26		2.26		2.26		2.26	

Finally, all tows conducted during the Diligence-2007-2 trip were compiled regardless of gear configuration. Bycatch levels that were found to be significantly different ($p < 0.05$) in the excluder dredge are listed in Table # 10, along with scallop catch statistics for these tows. A complete listing of results for all species landed is provided in Appendix # 26. Overall there were dramatic reductions in the retention of the

flatfish species in the excluder dredge, including: yellowtail flounder (-34%), sand dab (-51%), winter flounder (-41%), and summer flounder (-48%). While the numbers of these non-target species were reduced, the count of scallop bushels increased by 7-8%. Another interesting note was the continuously reduced amount of bottom trash (ie rocks, sponge, sand dollars, shells, starfish) collected in the excluder dredge. The scientific party noticed throughout this trip that fewer large boulders were coming up in the excluder dredge. It is possible that the dredge is excluding large rocks in a similar manner as it is set up to exclude large animals. This has an effect on scallop catch amounts, gear damage, as well as crew safety.

Table 10. Summary of scallop catch and species caught during trip Diligence-2007-2, all tows

All Good Tows														
Species	Scallop Bushels (all good tows)		Scallop Bushels(obs tows)		Trash Bushels		Yellowtail Fl.		Sand Dab		Winter Fl.		Summer Fl.	
	Excluder	Standard	Excluder	Standard	Excluder	Standard	Excluder	Standard	Excluder	Standard	Excluder	Control	Excluder	Control
Total Count	1406.2	1298.5	779.0	729.5	132.5	155.0	218	292	46	82	231	345	38	64
% Difference in Count	8.3%		6.8%		-14.5%		-25.3%		-43.9%		-33.0%		-40.6%	
Fish Count/Scallop Bushel Catch Ratio					0.40	0.53	0.66	1.01	0.14	0.28	0.70	1.19	0.11	0.22
% Difference in Catch Ratio					-25%		-34%		-51%		-41%		-48%	
Mean	15.1	14.0	14.4	13.5	2.5	2.9	4	5	1	2	4	6	1	1
Standard Error	0.5	0.4	0.6	0.5	0.2	0.2	0.5	0.7	0.2	0.4	0.4	0.6	0.1	0.2
Median	14.5	13.5	14.5	13.8	2.0	3.0	3	4.5	0	0	3	6	0	1
Mode	13.0	13.0	11.0	10.0	2.0	2.0	2	5	0	0	3	6	0	0
Standard Deviation	5.2	4.1	4.7	3.9	1.2	1.4	3.9	5.3	1.4	2.6	3.3	4.6	1.1	1.5
Sample Variance	26.6	17.0	22.1	14.8	1.5	2.0	14.9	27.6	2.1	6.9	10.9	21.6	1.2	2.4
Kurtosis	2.6	0.1	0.2	-0.1	0.8	0.6	12.91	14.09	3.05	6.79	1.28	3.72	1.61	3.91
Skewness	0.83	0.10	0.15	-0.28	0.13	0.11	2.96	3.17	1.86	2.41	1.18	1.78	1.53	1.82
Range	34.0	21.5	23.0	18.5	6.0	7.0	24	33	6	13	15	22	4	7
Minimum	3.0	3.5	3.0	3	0.0	0	0	0	0	0	0	0	0	0
Maximum	37.0	25	26.0	21.5	6.0	7	24	33	6	13	15	22	4	7
Confidence Level(95.0%)	1.06	0.85	1.28	1.05	0.33	0.39	1.05	1.43	0.39	0.72	0.90	1.27	0.30	0.42
Observations	93	93	54	54	54	54	54	54	54	54	54	54	54	54
Pearson Correlation	0.86	0.89	0.89	0.83	0.83	0.83	0.69	0.69	0.60	0.60	0.63	0.63	0.46	0.46
Hypothesized Mean Difference	0	0	0	0	0	0	0	0	0	0	0	0	0	0
df	92	92	53	53	53	53	53	53	53	53	53	53	53	53
α	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
t Stat	4.26	3.17	3.17	-3.83	-2.63	-2.63	-2.33	-2.33	-2.33	-2.33	-4.27	-4.27	-2.48	-2.48
P(T<=t) one-tail	0.000	0.000	0.001	0.000	0.006	0.006	0.012	0.012	0.012	0.012	0.000	0.000	0.008	0.008
t Critical one-tail	1.66	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67
P(T<=t) two-tail	0.000	0.000	0.003	0.000	0.011	0.011	0.024	0.024	0.024	0.024	0.000	0.000	0.016	0.016
t Critical two-tail	1.99	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01

Cletic-2007-6

The first 96 tows were conducted and 48 observed before any gear modification was made to either dredge. No significant difference in catch was observed between the two dredges with the exception of skate catch. Dredge B caught 16% less skate than dredge A. Scallop bushel count differed by 17 bushels for 2% more being landed by Dredge A. Interestingly the total count of fluke for each dredge was exactly the same at 72 animals. The count of clearnose skate was also the same with each dredge, totaling 108 animals.

Table 11. Summary of species caught during trip Celtic-2007-6 tows 1-95 before significant modifications were made

Tow 1-95: Dredge A = excluder dredge WITH turtle guards, Dredge B = excluder dredge WITHOUT turtle guards										
Species	Scallop Bushels (all good tows)		Scallop Bushels (obs tows)		Skates		Fluke		Clearnose Skate	
	A	B	A	B	A	B	A	B	A	B
Total Count	877.5	860.5	614.5	594.0	1436.0	1240.0	72	72	108	108
% Difference in Count	2.0%		3.5%		15.8%		0.0%		0.0%	
Fish Count/Scallop Bushel Catch Ratio					2.34	2.09	0.12	0.12	0.18	0.18
% Difference in Catch Ratio					12%		-3%		-3%	
Mean	12.7	12.5	12.8	12.4	29.9	25.8	2	2	2	2
Standard Error	0.6	0.5	0.7	0.5	2.1	2.1	0.2	0.2	0.3	0.4
Median	12.0	12.0	12.0	12.0	32.0	23.0	1	1	2	2
Mode	11.0	12.0	9.5	12.0	13.0	15.0	0	1	1	2
Standard Deviation	5.3	4.2	5.0	3.8	14.5	14.4	1.5	1.6	2.3	2.5
Sample Variance	28.6	17.4	25.5	14.2	209.9	208.6	2.2	2.6	5.2	6.1
Kurtosis	4.0	1.7	7.7	0.3	-0.8	0.7	0.19	5.55	3.42	3.25
Skewness	1.28	0.54	2.07	0.41	0.19	0.87	0.94	1.99	1.78	1.80
Range	33.5	25.0	30.5	18.0	56.0	68.0	5	8	10	10
Minimum	2.0	2	5.0	5	6.0	4	0	0	0	0
Maximum	35.5	27	35.5	23	62.0	72	5	8	10	10
Confidence Level(95.0%)	1.28	1.00	1.47	1.10	4.21	4.19	0.43	0.46	0.66	0.72
Observations	95		48		48		48		48	
Pearson Correlation	0.78	0.67	0.67	0.79	0.24	0.24	0.24	0.24	-0.07	-0.07
Hypothesized Mean Difference	0	0	0	0	0	0	0	0	0	0
α	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
P(T<=t) two-tail	0.728		0.436		0.004		0.103		0.280	

The last 13 tows were conducted with the frame chains removed from Dredge B. The frame chains remained on Dredge A, which then served as the control. This was done to explore the effect that the frame chains were having on catch relative to a dredge without and to previous tows with the chains on the dredge. During these last tows Dredge A, caught significantly less scallops than the dredge without frame chains, by a difference of 18%. There was also an observed 25% reduction in skates in Dredge A relative to Dredge B. In addition, the total count of fluke was 35% less in Dredge A. A summary of these observations are below. A table summarizing all species caught during these tows is found in Appendix # 28.

Table 12. Summary of species caught during trip Celtic-2007-6 tows 96-108 after the frame chains were removed from Dredge B

Tows 96-108: Dredge A = excluder dredge WITH turtle guards and frame chains, Dredge B = excluder dredge WITHOUT turtle guards and <i>frame chains removed</i>								
Species	Scallop Bushels (all good tows)		Scallop Bushels (obs tows)		Skates		Fluke	
Dredge	A	B	A	B	A	B	A	B
Total Count	174.5	201.0	164.5	188.0	863.0	1117.0	52	79
% Difference in Count	-13.2%		-12.5%		-22.7%		-34.2%	
Fish Count/Scallop Bushel Catch Ratio					1.40	1.88	0.08	0.13
% Difference in Catch Ratio					-25%		-36%	
Mean	13.4	15.5	13.7	15.7	71.9	93.1	4	7
Standard Error	0.6	0.6	0.6	0.6	7.9	6.9	0.8	0.8
Median	13.0	16.0	13.5	16.0	70.0	86.0	4.5	5.5
Mode	13.0	16.0	13.0	16.0	#N/A	85.0	7	9
Standard Deviation	2.1	2.2	1.9	2.2	27.5	24.0	2.8	2.9
Sample Variance	4.5	4.8	3.7	4.7	755.7	575.9	7.7	8.4
Kurtosis	-1.0	-0.4	-1.1	0.4	2.0	-0.3	-1.16	-0.96
Skewness	0.10	-0.69	0.23	-0.98	0.79	0.32	-0.35	0.42
Range	7.0	7.0	6.0	7.0	104.0	80.0	8	9
Minimum	10.0	11	11.0	11	32.0	53	0	3
Maximum	17.0	18	17.0	18	136.0	133	8	12
Confidence Level(95.0%)	1.28	1.33	1.22	1.37	17.47	15.25	1.76	1.85
Observations	13		12		12		12	
Pearson Correlation	0.33		0.20		0.77		0.27	
Hypothesized Mean Difference	0		0		0		0	
α	0.05		0.05		0.05		0.05	
P(T<=t) two-tail	0.012		0.023		0.002		0.045	

A summary of all tows observed during this trip is provided below in Table 13. A complete listing is available in Appendix # 29.

Table 13. Summary of species caught during trip Celtic-2007-6

All Good Tows-Select Species																
Species	Scallop Bushels (all good tows)		Scallop Bushels (obs tows)		Skates		Sand Dab		Fluke		Sea Robin		Cleanose Skate		Winter Flid.	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Total Count	1052.0	1061.5	779.0	782.0	2299.0	2357.0	18	18	124	151	168	154	199	186	0	3
% Difference in Count	-0.9%		-0.4%		-2.5%		0.0%		-17.9%		9.1%		7.0%		-100.0%	
Fish Count/Scallop Bushel Catch Ratio					3.74	3.97	0.03	0.03	0.20	0.25	0.27	0.26	0.32	0.31	0.00	0.01
% Difference in Catch Ratio					-6%		-3%		-21%		5%		3%		-100%	
Mean	12.8	12.9	13.0	13.0	38.3	39.3	0	0	2	3	3	3	3	3	0	0
Standard Error	0.5	0.4	0.6	0.5	3.1	4.1	0.1	0.1	0.3	0.4	0.4	0.4	0.4	0.4	0.0	0.0
Median	12.0	12.5	12.0	12.0	33.5	28.0	0	0	2	2	2	1	2	2	0	0
Mode	12.0	12.0	12.0	12.0	32.0	15.0	0	0	0	1	0	0	1	2	0	0
Standard Deviation	5.0	4.1	4.6	3.7	24.4	31.8	0.5	0.5	2.1	2.8	3.0	3.1	3.3	3.1	0.0	0.2
Sample Variance	24.7	16.5	21.1	14.0	595.1	1009.4	0.3	0.2	4.5	7.8	9.3	9.5	11.2	9.9	0.0	0.0
Kurtosis	4.6	1.3	8.8	-0.2	3.3	1.3	1.68	0.68	0.54	2.09	4.57	5.36	2.58	2.52	#DIV/0!	16.49
Skewness	1.27	0.27	2.06	0.06	1.44	1.39	1.58	1.32	1.11	1.59	1.67	1.94	1.56	1.51	#DIV/0!	4.24
Range	33.5	25.0	30.5	18.0	130.0	129.0	2	2	8	12	16	16	16	15	0	1
Minimum	2.0	2	5.0	5	6.0	4	0	0	0	0	0	0	0	0	0	0
Maximum	35.5	27	35.5	23	136.0	133	2	2	8	12	16	16	16	15	0	1
Confidence Level(95.0%)	1.09	0.89	1.19	0.97	6.30	8.21	0.14	0.13	0.55	0.72	0.79	0.80	0.86	0.81	0.00	0.06
Observations	82	82	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Pearson Correlation	0.75		1.00		0.99		0.88		0.97		0.99		0.98		#DIV/0!	
Hypothesized Mean Difference	0		0		0		0		0		0		0		0	
α	0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05	
P(T<=t) two-tail	0.752		0.620		0.550		0.505		0.142		0.208		0.572		0.083	

Westport-2007-2

No changes were made for the first 72 tows during the trip Westport-2007-2. Of those 72 tows, 67 were considered successful and 44 (66% of total) were observed by the scientist onboard. Throughout this trip, Dredge A had the F/V Celtic's bag configuration and Dredge B had the F/V Westport's preferred configuration. The first tows resulted in Dredge A catching 11% more scallops. Dredge A also caught fluke at a greater rate by 35%. Fourspot flounder were counted in a reduce amount in Dredge A by a rate of -63%. Additional species were landed during these tows, but no statistically significant difference between the two dredges was found. These species included: monkfish, black sea bass, sand dab, scup, and clearnose skate. A summary of these species can be found in Appendix # 30.

Table 14. Summary of species caught during trip Westport-2007-2 tows 1-72 before significant modifications were made

Tows 1-72: Dredge A = excluder dredge WITH turtle guards and Celtic's bag configuration, Dredge B = excluder dredge WITHOUT turtle guards and Westport's bag configuration										
Species	Scallop Bushels (all good tows)		Scallop Bushels (obs tows)		Fluke		Fourspot		Sea Robin	
Dredge	A	B	A	B	A	B	A	B	A	B
Total Count	1055.5	950.5	648.0	611.0	132	92	17	43	33	65
% Difference in Count	11.0%		6.1%		43.5%		-60.5%		-49.2%	
Fish Count/Scallop Bushel Catch Ratio					0.20	0.15	0.03	0.07	0.05	0.11
% Difference in Catch Ratio					35%		-63%		-52%	
Mean	15.6	14.0	14.7	13.9	3	2	0	1	1	1
Standard Error	0.7	0.8	1.0	1.0	0.4	0.3	0.1	0.2	0.2	0.3
Median	14.0	12.0	13.5	12.3	3	1	0	1	0	1
Mode	13.0	12.0	12.0	12.0	1	1	0	0	0	0
Standard Deviation	5.9	6.4	6.4	6.7	2.9	2.3	0.7	1.1	1.2	1.9
Sample Variance	34.8	41.6	40.9	44.5	8.6	5.3	0.4	1.3	1.4	3.5
Kurtosis	1.7	0.2	1.5	0.5	6.38	4.22	1.01	0.72	4.13	2.37
Skewness	1.01	0.79	0.79	0.92	2.16	1.85	1.48	1.16	2.00	1.66
Range	30.0	29.0	34.0	29.0	15	11	2	4	5	7
Minimum	6.0	4	2.0	4	0	0	0	0	0	0
Maximum	36.0	33	36.0	33	15	11	2	4	5	7
Observations	67	67	44	44	44	44	44	44	44	44
Confidence Level(95.0%)			1.95	2.03	0.89	0.70	0.20	0.34	0.35	0.57
Pearson Correlation	0.77		0.78		0.67		-0.05		0.23	
Hypothesized Mean Difference	0		0		0		0		0	
α	0.05		0.05		0.05		0.05		0.05	
P(T<=t) two-tail	0.004		0.208		0.009		0.005		0.018	

After tow 72, the frame chains were removed from Dredge B as had occurred during the previous trip, Celtic-2007-6. Dredge A again served as control to determine the effect of frame chains on catch levels. A total of 21 tows were completed in this manner, with 13 being observed. During these tows, Dredge A caught 17% less scallops. Dredge A also landed bycatch at a significantly reduce rate, including: skate (-30%), fluke (-21%), fourspot flounder (-76%), and sea robin (-75%). A summary of these observations is provided below in Table # 15. Monkfish were caught at a similar level and clearnose skate were not caught in a large enough quantity to determine if a significant difference occurred. A complete summary of all species caught during this test is available in Appendix # 30.

Table 15. Summary of species caught during trip Westport-2007-2 tows 73-94 after frame chains were removed from Dredge B

Tows 73-94: Dredge A = excluder dredge WITH turtle guards and Celtic's bag configuration, Dredge B = excluder dredge WITHOUT turtle guards and Westport's bag configuration and frame chains removed												
Species	Scallop Bushels (all good tows)		Scallop Bushels (obs tows)		Skates		Fluke		Fourspot		Sea Robin	
Dredge	A	B	A	B	A	B	A	B	A	B	A	B
Total Count	342.0	414.0	214.0	253.0	476.0	808.0	24	36	3	15	7	33
% Difference in Count	-17.4%		-15.4%		-41.1%		-33.3%		-80.0%		-78.8%	
Fish Count/Scallop Bushel Catch Ratio					2.22	3.19	0.11	0.14	0.01	0.06	0.03	0.13
% Difference in Catch Ratio					-30%		-21%		-76%		-75%	
Mean	16.3	19.7	16.5	19.5	36.6	62.2	2	3	0	1	3	1
Standard Error	1.6	1.5	2.1	2.0	8.8	12.8	0.5	0.6	0.1	0.3	0.5	0.2
Median	14.0	18.0	14.0	18.0	25.0	54.0	1	2	0	0	2	0
Mode	11.0	18.0	22.0	18.0	28.0	11.0	1	1	0	0	2	0
Standard Deviation	7.5	6.9	7.7	7.4	31.8	46.3	1.6	2.0	0.4	1.0	1.7	0.9
Sample Variance	56.3	47.0	58.8	54.4	1010.4	2142.3	2.6	4.2	0.2	0.9	2.8	0.8
Kurtosis	-1.0	-0.7	-0.5	-1.1	0.4	-0.7	-0.57	-1.21	0.09	2.70	0.35	4.84
Skewness	0.40	0.32	0.48	0.30	1.29	0.39	0.84	0.44	1.45	1.83	0.75	2.05
Range	25.0	24.0	25.0	23.0	91.0	148.0	5	6	1	3	6	3
Minimum	5.0	8	5.0	9	9.0	4	0	0	0	0	0	0
Maximum	30.0	32	30.0	32	100.0	152	5	6	1	3	6	3
Observations	21	21	13	13	13	13	13	13	13	13	13	13
Confidence Level(95.0%)	3.42	3.12	4.63	4.46	19.21	27.97	0.98	1.24	0.27	0.58	1.01	0.53

Tows 95 thru 100 were a final exploratory test of the fish escape vent concept. Holes were created in the twine top of Dredge B as previously described. During these last six tows, dredge B caught 19% more scallops and 28% less skates. The exact same number of fluke was caught by each dredge, as were the total counts of clearnose skate. Not enough monkfish or fourspot flounder were caught to determine if selectivity occurred while the holes were in place. A summary of all species caught is in Appendix # 32.

Table 16. Summary of species caught during trip Westport-2007-2 tows 95-100 after windows were created in the Dredge B's twine top

Tows 95-100: Dredge A = excluder dredge WITH turtle guards and Celtic's bag configuration, Dredge B = excluder dredge WITHOUT turtle guards

Species	Scallop Bushels (all good tows)		Scallop Bushels (obs tows)		Skates	
	A	B	A	B	A	B
Dredge						
Total Count	64.0	79.0	52.0	68.0	227.0	412.0
% Difference in Count	-19.0%		-23.5%		-44.9%	
Fish Count/Scallop Bushel Catch Ratio					4.37	6.06
% Difference in Catch Ratio					-28%	
Mean	10.7	13.2	10.4	13.6	45.4	82.4
Standard Error	1.6	1.8	1.9	2.2	4.9	5.2
Median	11.0	13.0	10.0	15.0	44.0	78.0
Mode	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Standard Deviation	3.9	4.5	4.3	4.9	10.9	11.6
Sample Variance	15.1	20.2	18.3	23.8	119.3	134.3
Kurtosis	-0.3	-2.1	-0.9	-2.7	-0.8	-2.4
Skewness	-0.18	0.13	0.12	-0.26	0.61	0.26
Range	11.0	11.0	11.0	11.0	27.0	27.0
Minimum	5.0	8	5.0	8	34.0	69
Maximum	16.0	19	16.0	19	61.0	96
Observations	6	6	5	5	5	5
Confidence Level(95.0%)	4.07	4.71	5.31	6.06	13.56	14.39
Pearson Correlation	0.81		0.88		-0.32	
Hypothesized Mean Difference	0		0		0	
α	0.05		0.05		0.05	
P(T<=t) two-tail	0.070		0.035		0.011	

A summary of the entire trip is provided in Appendix # 33. Species that were found to be caught at significantly different levels along with scallop catch statistics for the entire trip is shown below in Table 17.

Table 17. Summary of all tows conducted during trip Westport-2007-2

All Good Tows								
Species	Scallop Bushels (all good tows)		Scallop Bushels (obs tows)		Fourspot		Sea Robin	
	A	B	A	B	A	B	A	B
Dredge								
Total Count	1461.5	1443.5	914.0	932.0	22	63	43	104
% Difference in Count	1.2%		-1.9%		-65.1%		-58.7%	
Fish Count/Scallop Bushel Catch Ratio					0.02	0.07	0.05	0.11
% Difference in Catch Ratio					-64%		-58%	
Mean	15.4	15.2	14.7	15.0	0	1	1	2
Standard Error	0.6	0.7	0.8	0.9	0.1	0.1	0.1	0.2
Median	14.0	14.0	13.5	13.8	0	1	0	1
Mode	13.0	12.0	12.0	12.0	0	0	0	0
Standard Deviation	6.2	6.8	6.6	7.0	0.6	1.2	1.1	1.8
Sample Variance	39.0	46.2	43.8	48.9	0.4	1.4	1.2	3.3
Kurtosis	0.8	-0.1	0.8	-0.1	1.28	0.26	4.03	1.54
Skewness	0.85	0.68	0.76	0.75	1.51	1.08	1.96	1.38
Range	31.0	29.0	34.0	29.0	2	4	5	7
Minimum	5	4	2.0	4	0	0	0	0
Maximum	36	33	36.0	33	2	4	5	7
Observations	95	95	62	62	62	62	62	62
Confidence Level(95.0%)	1.27	1.38	1.68	1.78	0.15	0.30	0.28	0.46
Pearson Correlation	0.75		0.80		0.08		0.20	
Hypothesized Mean Difference	0		0		0		0	
α	0.05		0.05		0.05		0.05	
P(T<=t) two-tail	0.752		0.602		0.000		0.000	

Discussion

The first of the five tests conducted during these sea trials was the comparison of the performance and catch of a standard New Bedford dredge to that of the new excluder dredge. This test occurred during trip Diligence-2007-2. It showed that the excluder dredge is able to catch significantly lower amounts of important bycatch species such as yellowtail flounder and winter flounder relative to a traditional dredge. These results are consistent with previous field trials conducted during 2006 on different fishing vessels. A discussion as to possible reasons and implications of these reductions can be found in RSA Final Report NA05NMF4541293. In regard to performance during this trip, the scientific party noticed throughout this trip that fewer large boulders were coming up in the excluder dredge. It is possible that the dredge is excluding large rocks in a similar manner as it is set up to exclude large animals. This has an effect on scallop catch amounts, gear damage, as well as crew safety. One drawback found during the Diligence-2007-2 trips, was the poor performance of the turtle guards used. They could not stand up to the rigors of fishing on boulder bottom.

The concept behind the turtle guard is similar to that of a cattle catcher used on trains to keep large animals from being overtaken by the locomotive. If a turtle is overtaken by the dredge, a possible scenario is that it becomes caught between the cutting bar and the ocean floor. To prevent this, a series of 1-inch round stock of hardened steel bars were welded onto the cutting bar (figure # 12).



Figure 12. Photograph of turtle guards with space between cutting bar

It was expected that these turtle guards would contact the bottom thus closing the space where a turtle could get caught and help guide it out of the way of the dredge. It was also hypothesized that the turtle guards

feature would assist in excluding larger non-target species often caught in scallop dredges (i.e. barndoor skate, fluke, winter flounder, winter skate). Several earlier prototype designs of the excluder dredge incorporated this feature with mixed results. The first series of dredges tested employed rebar loops to function as the turtle guards. These rebar loops did not hold up to the rigors of scallop fishing and were worn down after 150 tows. The loops extended out from the cutting bar approximately 4 inches. This caused problems with the chain bag being caught up on the turtle guards, resulting in bad tows.

To overcome this problem, hardened steel was used instead of rebar. This change was tested during the last 2006 trips in the Hudson Canyon. The turtle guards made of hardened steel were not damaged during these trips. However, during the Diligence-2007-2 in Closed Area I, the turtle guards again faced hard bottom and were eventually broken off by the end of the trip. This is illustrated in Figure 13 below.



Figure 13. Photograph of broken turtle guards



Figure 14. Photograph of twine top hung on turtle guards

The next modification made to overcome this issue was to make the turtle guards flush against the cutting bar. An example of this design is shown in Figure 15. This greatly strengthened the turtle guards and reduced the chances of the twine top being hung up on protruding turtle guards. This design was tested during the last two 2007 trips to the Elephant Trunk Closed Area. A total of 182 tows were conducted with the new turtle guard design. The results from these trips showed that the flush turtle guard design held up without damage throughout both trips and did not cause entanglement problems. Although this configuration has yet to be tested on rocky bottom, it is expected to be a significant improvement over previous prototypes.



Figure 15. Photograph turtle guard flush with cutting bar

In addition to this performance testing done regarding the turtle guard design, a comparison test with an excluder dredge without turtle guards was completed during the 2007 trips. Although it had been found during the 2006 test trips that the excluder dredge did catch lower amounts of bycatch, what role each modification played was not certain. It was also not certain how the new turtle guard design would affect catch.

In order to test for the effect of the turtle guards on catch, paired tows were conducted using an excluder dredge with turtle guards and an excluder dredge without turtle guards. The two dredges were constructed using the same design characteristics with the exception of this test feature. Each dredge was also equipped with new chain bags that were identically configured.

This trial occurred during the trip Celtic-2007-6 tows 1-95. Results from these paired tows show that, for the most part, an excluder dredge with turtle guards fishes the same as an identically excluder dredge without turtle guards. Most species, including scallops, were caught in amazingly similar amounts. The count of scallop bushels was different by 2% and several priority bycatch species such as fluke and clearnose skate were landed in identical amounts. This is a positive result in that it confirms that there is consistency in catch levels by the overall excluder dredge design. Another point of interest is why little skates were landed in a lower quantity by the dredge without turtle guards while other species were not. The reason for this is unknown, although a number of non-design related variables such as weather, tows side, and direction could have played a role.

The next design feature tested was the presence of the frame chains on the excluder dredge. The frame chains were attached to the cutting bar and pressure plate on center between struts. The idea is that they reduce the size of the spaces between struts, thus reducing the opportunity of unwanted animals becoming captured or hung on the dredge frame. The chains do not completely block the spaces and are able to move so that scallops that are flushed up in front of the cutting bar can still enter the bag through the dredge frame.

The first test of this feature occurred during the trip Celtic-2007-6 tows 96 thru 108. Results from these tows show that the dredge with frame chains caught skate (-25%) and fluke (-36%) at a lower rate compared to a dredge without frame chains. This reduction is emphasized by the fact that during the previous 95 tows with the frame chains, there had been no significant difference between dredges. However the excluder dredge with frame chains also caught 13% less scallops.

Similar results were achieved during the second test that occurred during tows 73 thru 94 on Westport-2007-2. A reduction of skate by 30% and fluke by 21% is especially noticeable because during the first 72 tows with the chains, this dredge had been catching more of both species. Again, the scallop catch was reduced by the frame chains, this time by 17%, which is highlighted by the fact that the dredge had been ahead in scallops when both dredges had frame chains attached. One possible explanation for loss of scallop catch would be blockage occurring between struts due to the presence of the frame chains. The area fished had a high density of sulfur sponge, which was observed caught on the frame chains and clogging the opening.

The final test conducted during these three trips involved the chain bags used on the turtle excluder dredge. This variable was examined during the first 72 tows on the Westport-2007-2 trip. Prior to this trip all paired test tows had been conducting using identically configured chain bags using the specifications preferred by that particular vessel's crew. It had been noted several crews that traditional chain bag configurations may not be best suited to the excluder dredge frame. This is because the new frame had slightly different shape and dimensions for which the typical chain bag was developed.

Two different bag configurations were used during paired tows of the excluder dredge to get an idea as to the extent that the chain bag configurations had an affect on catch and handling of the dredge. One dredge had a dredge with the F/V Westport's preferred configuration with the other built according to the specifications applied by the F/V Celtic. The results show that the dredge using the Celtic bag caught 11% more scallops. The Celtic bag also had a 35% higher catch rate of fluke relative to the Westport bag. Differences in ease of handling the gear were also noted during this during this test. For example, the crew had a hard time dumping the dredge with the Celtic's bag. The scallops in the twine top kept sagging over the frame as seen if Figure 16. The captain mentioned that this was happening because the apron or twine top was too long. Scallops were also getting caught in the forward corners of Celtic's bag, making it impossible to shake them all out. This shake out problem also occurred during the Celtic trip. The captain said this is because the sweep was too short for the dredge frame, thus too tight and causing the bag to pinch during dumping. This resulted in loss of scallops, sometimes estimated to be upwards of a bushel per tow. Another application of this test could be in analyzing catch data and calibrating difference from past trips on the Celtic and Westport using the turtle excluder dredge.



Figure 16. Photograph of twine top hanging over frame during dumping of catch

Another test of the influence of different chain bags was also implemented during the Diligence-2007-2 trip. Both the standard New Bedford dredge and the excluder dredge were attached to the vessel's chain bag. After tow 35 the dredge frames exchanged both vessel side and chain bag in order to examine if there was any difference in the way these to similar chain bags fished or if there was a "side bias". Interestingly, the excluder dredge was less efficient after the switch. Prior to the switch, the excluder dredge was landing 14% more scallops than the control, where afterwards it landed just 2% more. The excluder dredge also caught more little skate and barndoor skate between tow 35 and 61, as compared to much less than the control during the first 34 tows. Other species continued to be caught at a reduced rate by the excluder dredge regardless of side fished or

bag used. Overall, the excluder dredge frame when compared to a standard dredge frame, has been shown on almost every trip, to have a significant lower bycatch rate, per pound of scallops caught, for all the key flatfish species and skates. Our attention now needs to focus on the scallop bag design to further improve upon the bycatch reductions.

Appendices

Appendix Table 2.

Bridge Data Log

F/V Celtic-2007-6

TRIP	TOW	DATE	START-TIME	END-TIME	TOTAL-TIME	LAT-START	LONG-START	LAT-END	LONG-END	KNOTS	DEPTH-FATH	WIRE-FATH	PORT-CATCH-BU	STRB-CATH-BU	BUSTED	HEADING	TIDE	SEA	WIND	COMMENTS
CELTIC-2007-6	101	11/11/2007	14:50	15:50	1:00	3838.8	7417.647	3842.925	7418.022	4.3	21	80 water	15	17	N	0			N 10-15	staight tows
CELTIC-2007-6	102	11/11/2007	15:54	16:50	0:56	3842.65	7417.917	3838.623	7417.794	4.2	21	80 water	17	16	N	180			N 10-15	capt 25 bag 18x10/20, 7xU/10
CELTIC-2007-6	103	11/11/2007	17:00	18:00	1:00	3838.709	7417.885	3843.224	7418.199	4.5	22	80 water	16	17.5	N	0			N 10-15	
CELTIC-2007-6	104	11/11/2007	18:09	19:10	1:01	3843.051	7418.018	3838.644	7417.746	4.4	20	80 water	14.5	11	N	180			N 10-15	
CELTIC-2007-6	105	11/11/2007	19:20	20:14	0:54	3838.823	7417.879	3842.982	7417.995	4.2	20	80 water	12	16	N				N 10-15	
CELTIC-2007-6	106	11/11/2007	20:25	21:22	0:57	3842.79	7417.858	3838.593	7417.73	4.8	21	80 water	12	14	N				N 10-15	
CELTIC-2007-6	107	11/11/2007	21:32	22:23	0:51	3838.722	7417.809	3842.523	7417.899	4.2	22	80 water	13	14.5	N				N 10-15	
CELTIC-2007-6	108	11/11/2007	22:35	23:25	0:50	3842.264	7417.792	3838.6	7417.465	4.3	20	80 water	11	13	N				N 10-15	
CELTIC-2007-6	109	11/11/2007	23:37	0:32	0:55	3838.772	7417.529	3842.73	7417.783	4.3	21	80 water	10	13	N				N 10-15	

Appendix Table 3. Bridge Data Log F/V Westport-2007-2

BRIDGE LOG-WESTPORT-2007-2			ELEPHANT TRUNK RSA																
TRIP	TOW	DATE	START-TIME	END-TIME	TOTAL-TIME	LAT-START	LONG-START	LAT-END	LONG-END	KNOTS	DEPTH-FATH	WIRE-FATH	PORT-CATCH-BU	STRB-CATH-BU	BUSTED	HEADING	SEA	WIND	COMMENTS
WESTPORT-2007-2	51	11/24/2007	16:24	17:08	0:44	3847.6	7409.86	3848.31	7405.87	4.3	24	80 water	27	21	N		calm	calm	
WESTPORT-2007-2	52	11/24/2007	17:20	18:11	0:51	3848.41	7405.22	3848.85	7401.21	3.8	24/27	75	6	12	N	e/w	calm	calm	turn starb
WESTPORT-2007-2	53	11/24/2007	18:40	19:38	0:58	3848.91	7400.45	3848.87	7359.95	3.8		75	12	17	N	w	calm	calm	small pile
WESTPORT-2007-2	54	11/24/2007	19:49	20:36	0:47	3848.87	7400	3848.65	7504.42	3.8	26	75	8	9	N	se	calm	calm	
WESTPORT-2007-2	55	11/24/2007	21:35	22:06	0:31	3845.94	7359.53	3844.68	7357.24	3.8	26/27	75	26	18	N	se	calm	calm	
WESTPORT-2007-2	56	11/24/2007	23:20	0:20	1:00	3844.26	7355.88	3843.8	7355.65	3.8	25		8	11	N		calm	calm	monkey dung
WESTPORT-2007-2	57	11/25/2007	0:32	1:24	0:52	3844.04	7356.03	3845.86	7359.91	3.8			18	24	N		calm	calm	monkey dung
WESTPORT-2007-2	58	11/25/2007	2:37	3:39	1:02	3842.19	7356.07	3842.3	7355.76	3.8		85	12	14	N	nnw/sse	calm	calm	turn starb
WESTPORT-2007-2	59	11/25/2007	4:50	5:56	1:06	3842.75	7354.15	3842.67	7354.79	4.1		90	10	13	N	nw/se	calm	calm	turn port
WESTPORT-2007-2	60	11/25/2007	6:17	7:15	0:58	3842.16	7355.15	3842.17	7354.58	4.1	26	80	33	36	N	sw/ne	calm	calm	turn port, lots of really small seed in both piles
WESTPORT-2007-2	61	11/25/2007	7:25	7:53	0:28	3841.98	7354.28	3840.28	7354.26	4	27	80	14	17	N		calm	variable	
WESTPORT-2007-2	62	11/25/2007	10:43	11:17	0:34	3840.23	7353.48	3840.41	7356.35	4	27	80	8	11	N	w	calm	variable	
WESTPORT-2007-2	63	11/25/2007	11:28	12:07	0:39	3840.39	7356.04	3840.13	7352.7	4	27		12	14	N		calm		
WESTPORT-2007-2	64	11/25/2007	12:13	12:55	0:42	3839.98	7352.79	3840.13	7355.91	4.2	26		7	12	N	e	calm		
WESTPORT-2007-2	65	11/25/2007	14:39	15:12	0:33	3840.25	7356.33	3840.54	7353.62	nk	26		10	11	N	w	calm		calm, nice out
WESTPORT-2007-2	66	11/25/2007	15:26	16:16	0:50	3840.49	7353.75	3839.48	7352.57	3.8	26		17	16	N		calm		
WESTPORT-2007-2	67	11/25/2007	16:27	17:22	0:55	3838.39	7357.6	3839.35	7352.97	4.1	27	90	10	12	N	e	calm		
WESTPORT-2007-2	68	11/25/2007	19:13	20:07	0:54	3840.46	7353.21	3839.43	7357.72	4.1	27	85	10	13	N	w	calm		monkey dung, really small seed
WESTPORT-2007-2	69	11/25/2007	20:15	21:11	0:56	3839.68	7357.66	3842.45	7354.61	4.1	27	85	10	13	N	ne	calm		
WESTPORT-2007-2	70	11/25/2007	22:14	23:06	0:52	3839.66	7354.34	3843.04	7353.2	nk	27	90	15	13	N	s	calm	se-10-20	
WESTPORT-2007-2	71	11/25/2007	23:15	0:27	1:12	3842.98	7353.03	3838.39	7353.65	4	26	80	22	26	N	nnw			turn port
WESTPORT-2007-2	72	11/26/2007	0:35	1:36	1:01	3838.62	7353.83	3838.27	7354.15	4	26	80	14	15	N				cut pressure plate chains off of port, dredge B, turn port
WESTPORT-2007-2	73	11/26/2007	1:52	3:00	1:08	3838.5	7354.32	3838.09	7354.85	4.1	26	80	12	13	N				1st tow without pressure plate chains on B, turn port, monkey dung
WESTPORT-2007-2	74	11/26/2007	4:28	5:28	1:00	3839.53	7355.93	3838.84	7358.4	4.1	26	80	29	22	N				turn port, monkey dung
WESTPORT-2007-2	75	11/26/2007	5:43	6:38	0:55	3838.78	7358.5	3835.14	7400.02	4.1	28	90	22	25	N				
WESTPORT-2007-2	76	11/26/2007	10:25	11:36	1:11	3835.07	7359.14	3834.97	7359.68	4.1	29/28	95	18	13	N				turn port
WESTPORT-2007-2	77	11/26/2007	11:45	12:53	1:08	3835.1	7359.62	3835.41	7359.84	4.1	29	95	20	10	N				hole in starb, diamond off, hanger, turn port
WESTPORT-2007-2	78	11/26/2007	14:16	15:14	0:58	3835.86	7358.96	3835.52	7359.52	4.1	29	95	18	14	N				turn starb
WESTPORT-2007-2	79	11/26/2007	15:24	16:29	1:05	3835.62	7359.5	3835.8	7359.59	4.3	29	90	32	30	N				turn port
WESTPORT-2007-2	80	11/26/2007	16:38	17:34	0:56	3835.38	7359.98	3837.04	7359.28	4.5	29	90	28	29	N				turn port
WESTPORT-2007-2	81	11/26/2007	20:20	21:26	1:06	3834.07	7400.26	3834.01	7359.96	4.3	30	90	24	18	N	NNW	10	SSW 20-2	turn port
WESTPORT-2007-2	82	11/26/2007	23:20	0:19	0:59	3833.85	7358.75	3837.93	7358.82	4.3	30	95	16	11	N	NNE	10	SW 30 - 40	
WESTPORT-2007-2	83	11/27/2007	1:54	2:59	1:05	3834.04	7400.69	3838.36	7358.81	4.2	39	95	19	11	N	NNE	10	SW 25	
WESTPORT-2007-2	84	11/27/2007	4:05	5:29	1:24	3835.16	7359.94	3835.55	7400.24	4.2	29	95	25	24	N		10		double turn starb
WESTPORT-2007-2	85	11/27/2007	5:43	7:13	1:30	3836.03	7359.68	3834.9	7359.73	4.2	29	95	24	22	N		10		turn starb
WESTPORT-2007-2	86	11/27/2007	8:37	9:31	0:54	3835.99	7358.72	3836.59	7358.05	4.2	29	95	19	18	N		10		turn starb
WESTPORT-2007-2	87	11/27/2007	10:42	11:47	1:05	3840.4	7357.07	3840.24	7356.39	4.2	27	85	15	14	N		10	NW 25 - 3	turn starb
WESTPORT-2007-2	88	11/27/2007	11:57	13:06	1:09	3839.98	7355.91	3839.85	7355.27	4.2	27	85	11	10	N		10		turn starb
WESTPORT-2007-2	89	11/27/2007	13:21	14:36	1:15	3839.54	7355.02	3838.04	7357.74	4.2	27	90	18	11	N		10		turn starb
WESTPORT-2007-2	90	11/27/2007	16:22	17:32	1:10	3838.55	7358.84	3837.56	7401.06	4.2	27	95/100	18	12	N		10		turn starb, 100 G, nice meats
WESTPORT-2007-2	91	11/27/2007	17:43	18:55	1:12	3837.25	7400.84	3835.58	7402.42	4.4	28/30	95/100	32	26	N	SE/W			turn starb
WESTPORT-2007-2	92	11/27/2007	19:11	20:08	0:57	3835.5	7402.17	3835.25	7400.94	4.3	30		12	8	N				turn port
WESTPORT-2007-2	93	11/27/2007	22:17	23:17	1:00	3839.34	7359.15	3838.63	7359.13	4.3	28		14	5	N				turn starb
WESTPORT-2007-2	94	11/27/2007	23:26	0:37	1:11	3838.45	7358.68	3838.45	7355.29	4.3	28	90/100	8	6	N		14		sloppy out again, turn port
WESTPORT-2007-2	95	11/28/2007	1:00	2:05	1:05	3838	7354.32	3838.77	7358.15	4.3	27	90	9	8	N				1st corners out or twine top on B, port, upper corners
WESTPORT-2007-2	96	11/28/2007	2:18	3:19	1:01	3838.51	7357.42	3838.57	7358.18	4.3	27	90	8	5	N			NW 35-40	shitter, turn starb
WESTPORT-2007-2	97	11/28/2007	3:30	4:33	1:03	3838.28	7359.73	3838.33	7400.87	4.3	27	100	15	13	N				turn starb
WESTPORT-2007-2	98	11/28/2007	4:46	5:52	1:06	3838.04	7400.39	3838.78	7401.38	4.3	27	100	19	16	N				turn starb
WESTPORT-2007-2	99	11/28/2007	6:04	7:22	1:18	3838.59	7401.13	3839	7401.29	4.3	27	100	17	10	N				turn port
WESTPORT-2007-2	100	11/28/2007	8:15	9:13	0:58	3841.21	7357.59	3843.17	7354.49	4.3	27	100	11	12	N	SE/NE			

SCALLOP SHELL HEIGHTS CELTIC-2007-6

A = Experimental Dredge W/ B = Experimental Dredge WITHOUT TEETH

TOW #	6	6	8	8	10	10	11	11	27	27	28	28	29	29	30	30	31	31	32	32	33	33	34	34	35	35	36	36	38	38	50	50	51	51	52	52	53	53	55	55	57	57	58	58	60	60	76	76	TOTAL	TOTAL																																																
DREDGE	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B																																																
SHELL HEIGHT (mm)																																																	TOTAL	TOTAL																																																
45-49																																																	1	0																																																
50-54																																																	2	0																																																
55-59																																																	6	3																																																
60-64																																																	20	15																																																
65-69																																																	50	31																																																
70-74																																																	81	61																																																
75-79																																																	59	24																																																
80-84																																																	24	18																																																
85-89																																																	9	15																																																
90-94																																																	8	19																																																
95-99																																																	32	39																																																
100-104																																																	90	95																																																
105-109																																																	153	169																																																
110-114																																																	228	220																																																
115-119																																																	313	313																																																
120-124																																																	368	394																																																
125-129																																																	382	364																																																
130-134																																																	350	341																																																
135-139																																																	289	295																																																
140-144																																																	162	170																																																
145-149																																																	92	64																																																
150-154																																																	25	15																																																
155-159																																																	3	3																																																
TOTAL PER TOW	102	101	127	134	126	134	104	109	104	96	109	119	108	95	114	115	104	129	104	130	118	104	113	112	121	109	104	120	101	105	100	101	117	95	126	105	121	114	113	115	98	104	124	74	101	94	109	105	2747	2668																																																
BUSHELS MEASURED	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	48	14																																														

Appendix Table 15. Skate Length Frequency Log

F/V Celtic-2007-6

SKATE LENGTHS CELTIC-2007-6	A = Experimental Dredge WITH TEETH																B = Experimental Dredge WITHOUT TEETH																TOTAL		%																											
TOW #	10	10	11	11	27	27	28	28	29	29	30	30	31	31	33	33	34	34	51	51	59	59	72	72	73	73	74	74	76	76	79	79	TOTAL	TOTAL																												
DREDGE	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	E	C	E	C																										
LENGTH (cm)																																					TOTAL	TOTAL																								
16-20																																					6	2																								
21-25	2	1	2	1				1	1	1	2	1	2	2	1	3	2	4	1			1			1	1	0	2	4	2	9	10	2.14%	3.40%																												
26-30	7	7	0	3	1			1			1	2	2	2	8	4	2	2	0	1	1	1	5	2	1	2	5	8	1	50	26	5.94%	9.52%																													
31-35	7	4	2	3	1	2	1	1			2	3	9	4	2	3	7	4	6	6	0	0	2	7	3	2	3	2	7	5	62	38	11.88%	8.84%																												
36-40	3	1		2	5	3	2		1	2		3	9	4	2	3	7	4	6	6	0	0	2	7	3	2	3	2	7	5	62	38	14.73%	12.93%																												
41-45	2	2	4	1	6	3	16	9	14	3	16	7	24	14	16	13	16	19	21	11	24	18	9	0	13	8	6	3	10	5	13	197	129	46.79%	43.88%																											
46-50	1	1	4	2	1	1	3	2	6	3	3	3	5	8	8	5	9	5	7	5	8	4	2	1	4	1	2	4	8	6	11	72	61	17.10%	20.75%																											
TOTAL MEASURED	22	15	13	12	13	10	20	14	23	7	24	15	43	28	33	22	43	35	37	29	40	27	13	4	32	0	15	12	17	28	33	36	421	294																												

Appendix Table 21. Summary of Tows 1-35 F/V Diligence-2007-2

Diligence-2007-2
Tows 1-35: Experimental Dredge on Starboard Side

Species	Scallop Bushels (all good tows)		Scallop Bushels(obs tows)		Trash Bushels		Skates		Barndoor		Winter Skate		Monk		Yellowtail Flid.		Sand Dab		Winter Flid.		Grey Sole		Summer Flid.		Fourspot Flid.		
Dredge	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	
Total Count	573.7	502.5	331.0	290.5	56.0	60.0	1030	1170	206	213	46	28	384	383	108	142	1	5	77	118	28	35	7	12	168	183	
% Difference in Count	14.2%		13.9%		-6.7%		-12.0%		-3.3%		64.3%		0.3%		-23.9%		-80.0%		-34.7%		-20.0%		-41.7%		-8.2%		
Fish Count/Scallop Bushel Catch Ratio					0.17	0.21	3.11	4.03	0.62	0.73	0.14	0.10	1.16	1.32	0.33	0.49	0.00	0.02	0.23	0.41	0.08	0.12	0.02	0.04	0.51	0.63	
% Difference in Catch Ratio					-18%		-23%		-15%		44%		-12%		-33%		-82%		-43%		-30%		-49%		-19%		
Mean	16.4	14.4	16.6	14.5	2.8	3.0	52	59	10	11	2	1	19	19	5	7	0	0	4	6	1	2	0	1	8	9	
Standard Error	1.1	0.7	1.2	0.8	0.3	0.4	8.7	10.0	1.4	1.7	0.4	0.3	1.1	1.1	1.2	1.6	0.1	0.3	0.6	0.9	0.5	0.5	0.2	0.2	1.1	0.9	
Median	16.0	15.0	16.8	15.3	3.0	3.0	32	33	10.5	12	2.5	1	20	18.5	4	5	0	0	3	5.5	0.5	1	0	0	7	9.5	
Mode	13.0	16.0	11.0	16.0	3.0	3.0	119	17	0	1	3	0	21	16	4	3	0	0	3	3	0	0	0	0	4	10	
Standard Deviation	6.4	4.4	5.2	3.6	1.3	1.7	39.0	44.9	6.1	7.5	1.9	1.4	4.8	5.1	5.2	7.3	0.2	1.1	2.8	4.2	2.2	2.4	0.8	1.0	5.0	4.1	
Sample Variance	41.1	19.1	26.7	12.8	1.6	2.7	1522.1	2012.2	37.6	55.7	3.8	1.9	23.4	25.9	27.5	52.8	0.1	1.3	7.7	17.8	5.0	6.0	0.7	1.1	25.0	16.7	
Kurtosis	1.8	0.1	-0.5	-0.6	0.9	1.0	-0.57	-0.66	-0.89	-1.09	2.49	-0.87	0.25	-0.12	8.25	8.60	20.00	20.00	0.97	11.97	2.03	3.09	5.95	1.04	0.34	-0.63	
Skewness	0.87	-0.06	0.08	-0.53	-0.92	0.23	0.97	0.94	-0.32	-0.02	1.14	0.62	-0.48	0.78	2.61	2.77	4.47	4.47	1.12	3.12	1.80	1.78	2.50	1.54	0.91	-0.14	
Range	31.0	20.0	18.5	13.0	5.0	7.0	111	122	20	24	8	4	19	18	23	32	1	5	11	20	7	9	3	3	19	15	
Minimum	6.0	5	7.5	7	0.0	0	15	17	0	0	0	0	8	13	1	1	0	0	2	0	0	0	0	0	1	1	
Maximum	37.0	25	26.0	20	5.0	7	126	139	20	24	8	4	27	31	24	33	1	5	11	22	7	9	3	3	20	16	
Confidence Level(95.0%)	2.20	1.50	2.42	1.67	0.60	0.77	18.26	20.99	2.87	3.49	0.91	0.65	2.27	2.38	2.45	3.40	0.10	0.52	1.30	1.97	1.05	1.15	0.38	0.49	2.34	1.91	
Observations	35	35	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Pearson Correlation	0.92		0.94		0.94		0.98		0.74		0.11		0.05		0.92		1.00		0.28		0.58		0.79		0.47		
Hypothesized Mean Difference	0		0		0		0		0		0		0		0		0		0		0		0		0		
df	34		19		19		19		19		19		19		19		19		19		19		19		19		
α	0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		
t Stat	4.12		4.17		-1.45		-3.11		-0.31		1.77		0.03		-2.42		-1.00		-2.11		-0.73		-1.75		-0.71		
P(T<=t) one-tail	0.000		0.000		0.081		0.003		0.381		0.046		0.487		0.013		0.165		0.024		0.239		0.048		0.244		
t Critical one-tail	1.69		1.73		1.73		1.73		1.73		1.73		1.73		1.73		1.73		1.73		1.73		1.73		1.73		
P(T<=t) two-tail	0.000		0.001		0.163		0.006		0.762		0.092		0.974		0.026		0.330		0.048		0.477		0.096		0.488		
t Critical two-tail	2.03		2.09		2.09		2.09		2.09		2.09		2.09		2.09		2.09		2.09		2.09		2.09		2.09		

Appendix Table 22. Summary of Tows 36-61 F/V Diligence-2007-2

Diligence-2007-2

Tows 36-61 : Experimental Dredge on Port Side with Different Bag

Species	Scallop Bushels (all good tows)		Scallop Bushels(obs tows)		Trash Bushels		Skates		Barndoor		Winter Skate		Monk		Yellowtail Flid.		Sand Dab		Winter Flid.		Grey Sole		Summer Flid.		Fourspot Flid.		
Dredge	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	
Total Count	347.5	340.5	182.0	177.5	29.0	32.0	1272	1144	86	75	29	24	165	183	38	43	6	21	64	102	4	5	12	16	46	65	
% Difference in Count	2.1%		2.5%		-9.4%		11.2%		14.7%		20.8%		-9.8%		-11.6%		-71.4%		-37.3%		-20.0%		-25.0%		-29.2%		
Fish Count/Scallop Bushel Catch Ratio					0.09	0.11	3.84	3.94	0.26	0.26	0.09	0.08	0.50	0.63	0.11	0.15	0.02	0.07	0.19	0.35	0.01	0.02	0.04	0.06	0.14	0.22	
% Difference in Catch Ratio					-20%		-2%		1%		6%		-21%		-22%		-75%		-45%		-30%		-34%		-38%		
Mean	14.5	14.2	14.0	13.7	2.2	2.5	98	88	7	6	2	2	13	14	3	3	0	2	5	8	0	0	1	1	4	5	
Standard Error	0.8	0.8	1.1	1.0	0.4	0.4	15.4	14.1	1.3	1.1	0.8	0.5	1.9	1.5	0.5	0.7	0.3	0.6	1.0	1.6	0.2	0.2	0.2	0.4	0.7	0.9	
Median	14.3	13.0	14.0	13.0	2.0	2.0	117	97	6	4	1	1	14	12	2	4	0	0	4	7	0	0	1	1	3	4	
Mode	15.0	12.0	18.5	13.0	2.0	2.0	117	141	6	4	0	0	16	12	2	4	0	0	3	4	0	0	0	1	3	4	
Standard Deviation	3.7	4.1	4.0	3.6	1.6	1.6	55.6	50.9	4.5	3.9	2.9	2.0	6.7	5.5	2.0	2.4	1.0	2.3	3.6	5.6	0.6	0.8	0.9	1.6	2.7	3.2	
Sample Variance	14.0	16.5	15.7	13.1	2.5	2.4	3089.8	2586.0	20.6	14.9	8.5	3.8	44.9	30.2	3.9	5.9	0.9	5.4	13.2	31.5	0.4	0.6	0.7	2.5	7.3	10.0	
Kurtosis	0.5	-0.6	0.0	-0.8	1.8	-0.8	-0.95	-1.34	0.41	-0.85	3.38	-0.26	-1.53	-0.23	-0.77	-1.06	3.58	1.01	-0.55	0.14	3.71	1.62	-1.68	7.47	0.18	5.50	
Skewness	0.33	0.37	-0.09	0.14	0.88	-0.15	-0.37	-0.44	0.85	0.65	1.75	0.73	-0.16	0.39	0.20	0.15	2.09	1.39	0.59	0.64	2.05	1.76	0.16	2.50	0.91	2.13	
Range	16.0	15.5	14.0	11.5	6.0	5.0	167	131	15	12	10	6	18	20	6	7	3	7	12	19	2	2	2	6	9	12	
Minimum	7.0	7.5	7.0	7.5	0.0	0	11	11	1	1	0	0	4	5	0	0	0	0	0	1	0	0	0	0	0	2	
Maximum	23.0	23	21.0	19	6.0	5	178	142	16	13	10	6	22	25	6	7	3	7	12	20	2	2	2	6	9	14	
Confidence Level(95.0%)	1.58	1.71	2.39	2.18	0.96	0.94	33.59	30.73	2.74	2.33	1.76	1.18	4.05	3.32	1.19	1.47	0.58	1.41	2.20	3.39	0.38	0.46	0.52	0.96	1.63	1.91	
Observations	24	24	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
Pearson Correlation	0.80		0.88		0.86		0.91		0.73		0.33		0.61		0.20		0.27		0.78		0.77		0.32		0.78		
Hypothesized Mean Difference	0		0		0		0		0		0		0		0		0		0		0		0		0		
df	23		12		12		12		12		12		12		12		12		12		12		12		12		
α	0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		
t Stat	0.57		0.65		-1.00		1.53		0.97		0.47		-0.91		-0.49		-1.83		-2.95		-0.56		-0.72		-2.66		
P(T<=t) one-tail	0.287		0.264		0.169		0.076		0.175		0.322		0.192		0.316		0.046		0.006		0.292		0.244		0.010		
t Critical one-tail	1.71		1.78		1.78		1.78		1.78		1.78		1.78		1.78		1.78		1.78		1.78		1.78		1.78		
P(T<=t) two-tail	0.574		0.528		0.337		0.153		0.349		0.645		0.383		0.631		0.091		0.012		0.584		0.487		0.021		
t Critical two-tail	2.07		2.18		2.18		2.18		2.18		2.18		2.18		2.18		2.18		2.18		2.18		2.18		2.18		

Appendix Table 23. Summary of Tows 1-61 F/V Diligence-2007-2

Diligence-2007-2
Tows 1-61 : Experimental Dredge Before Modifications

Species	Scallop Bushels (all good tows)		Scallop Bushels(obs tows)		Trash Bushels		Skates		Barndoor		Winter Skate		Monk		Yellowtail Fid.		Sand Dab		Winter Fid.		Grey Sole		Summer Fid.		Fourspot Fid.		
	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	
Total Count	921.2	843.0	513.0	468.0	85.0	92.0	2302	2314	292	288	75	52	549	566	146	185	7	26	141	220	32	40	19	28	214	248	
% Difference in Count	9.3%		9.6%		-7.6%		-0.5%		1.4%		44.2%		-3.0%		-21.1%		-73.1%		-35.9%		-20.0%		-32.1%		-13.7%		
Fish Count/Scallop Bushel Catch Ratio					0.26	0.32	6.95	7.97	0.88	0.99	0.23	0.18	1.66	1.95	0.44	0.64	0.02	0.09	0.43	0.76	0.10	0.14	0.06	0.10	0.65	0.85	
% Difference in Catch Ratio					-19%		-13%		-11%		27%		-15%		-31%		-76%		-44%		-30%		-40%		-24%		
Mean	15.6	14.3	15.5	14.2	2.6	2.8	70	70	9	9	2	2	17	17	4	6	0	1	4	7	1	1	1	1	6	8	
Standard Error	0.7	0.5	0.8	0.6	0.2	0.3	8.9	8.5	1.0	1.2	0.4	0.3	1.1	1.0	0.8	1.1	0.1	0.3	0.5	0.8	0.3	0.4	0.2	0.2	0.8	0.7	
Median	15.0	14.0	15.5	14.5	3.0	3.0	57	64	8	8	2	1	18	16	4	4	0	0	3	6	0	0	0	0	5	7	
Mode	12.0	13.0	21.0	16.0	3.0	3.0	117	137	6	1	0	0	21	20	2	4	0	0	3	7	0	0	0	0	4	5	
Standard Deviation	5.5	4.2	4.8	3.6	1.4	1.6	50.9	48.8	5.8	6.7	2.3	1.6	6.4	5.8	4.4	6.1	0.6	1.8	3.1	4.8	1.8	2.1	0.9	1.3	4.8	4.2	
Sample Variance	30.5	17.8	23.3	12.7	2.0	2.6	2591.3	2378.7	33.4	44.5	5.5	2.6	41.2	33.1	19.3	37.1	0.4	3.2	9.8	23.3	3.4	4.2	0.8	1.7	23.4	17.9	
Kurtosis	2.7	-0.2	-0.2	-0.9	0.3	0.4	-1.05	-1.51	-1.02	-0.67	3.03	-0.08	-0.32	0.01	12.12	12.95	11.80	4.77	0.06	3.27	5.23	6.10	0.54	6.71	1.12	-0.90	
Skewness	1.04	0.09	0.22	-0.25	-0.09	0.13	0.52	0.35	0.16	0.51	1.51	0.79	-0.61	0.32	3.04	3.25	3.40	2.36	0.89	1.69	2.43	2.35	1.28	2.29	1.15	0.46	
Range	31.0	20.0	19.0	13.0	6.0	7.0	167	131	20	24	10	6	23	26	24	33	3	7	12	21	7	9	3	6	20	15	
Minimum	6.0	5	7.0	7	0.0	0	11	11	0	0	0	0	4	5	0	0	0	0	0	1	0	0	0	0	0	1	
Maximum	37.0	25	26.0	20	6.0	7	178	142	20	24	10	6	27	31	24	33	3	7	12	22	7	9	3	6	20	16	
Confidence Level(95.0%)	1.44	1.10	1.71	1.26	0.50	0.57	18.05	17.29	2.05	2.37	0.83	0.57	2.28	2.04	1.56	2.16	0.23	0.64	1.11	1.71	0.65	0.73	0.31	0.46	1.71	1.50	
Observations	59	59	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
Pearson Correlation	0.86		0.91		0.90		0.93		0.76		0.23		0.47		0.88		0.44		0.56		0.63		0.58		0.64		
Hypothesized Mean Difference	0		0		0		0		0		0		0		0		0		0		0		0		0		
df	58		32		32		32		32		32		32		32		32		32		32		32		32		
α	0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		
t Stat	3.55		3.55		-1.75		-0.11		0.16		1.59		-0.47		-2.23		-2.04		-3.42		-0.82		-1.47		-1.53		
P(T<=t) one-tail	0.000		0.001		0.045		0.455		0.438		0.061		0.321		0.016		0.025		0.001		0.209		0.076		0.068		
t Critical one-tail	1.67		1.69		1.69		1.69		1.69		1.69		1.69		1.69		1.69		1.69		1.69		1.69		1.69		
P(T<=t) two-tail	0.001		0.001		0.090		0.910		0.875		0.122		0.643		0.033		0.050		0.002		0.418		0.152		0.136		
t Critical two-tail	2.00		2.04		2.04		2.04		2.04		2.04		2.04		2.04		2.04		2.04		2.04		2.04		2.04		

Appendix Table 24. Summary of Tows 63-81 F/V Diligence-2007-2

Diligence-2007-2
Tows 63-81: Drop Chains on Experimental Dredge

Species	Scallop Bushels (all good tows)		Top Bushels(obs tows)		Trash Bushels		Skates		Barndoor		Winter Skate		Monk		Yellowtail Flid.		Sand Dab		Winter Flid.		Grey Sole		Summer Flid.		Fourspot Flid.		
	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental
Total Count	263.0	239.5	146.0	138.0	26.0	30.0	936	846	18	23	19	16	77	70	44	59	23	30	57	66	0	0	17	19	26	40	
% Difference in Count	9.8%		5.8%		-13.3%		10.6%		-21.7%		18.8%		10.0%		-25.4%		-23.3%		-13.6%		#DIV/0!		-10.5%		-35.0%		
Fish Count/Scallop Bushel Catch Ratio					0.08	0.10	2.83	2.91	0.05	0.08	0.06	0.06	0.23	0.24	0.13	0.20	0.07	0.10	0.17	0.23	0.00	0.00	0.05	0.07	0.08	0.14	
% Difference in Catch Ratio					-24%		-3%		-31%		4%		-3%		-35%		-33%		-24%		#DIV/0!		-21%		-43%		
Mean	14.6	13.3	13.3	12.5	2.4	2.7	85	77	2	2	2	1	7	6	4	5	2	3	5	6	0	0	2	2	2	4	
Standard Error	0.8	0.7	0.9	1.0	0.2	0.3	6.8	4.8	0.5	0.6	0.4	0.3	0.7	0.8	0.7	1.0	0.5	0.7	1.1	0.9	0.0	0.0	0.5	0.4	0.4	0.4	
Median	15.0	13.8	13.0	13.0	2.0	2.0	89	81	2	2	2	1	7	7	4	5	2	2	4	6	0	0	1	2	2	3	
Mode	15.0	10.0	15.0	13.0	2.0	2.0	95	#N/A	0	0	2	1	7	9	4	5	2	2	3	5	0	0	0	1	1	3	
Standard Deviation	3.6	3.0	2.8	3.4	0.7	1.1	22.6	15.9	1.6	2.1	1.5	1.0	2.3	2.6	2.3	3.3	1.6	2.4	3.7	3.1	0.0	0.0	1.6	1.3	1.4	1.3	
Sample Variance	12.6	9.2	8.0	11.4	0.5	1.2	509.1	253.1	2.5	4.5	2.2	1.1	5.4	6.9	5.4	10.7	2.5	5.8	14.0	9.4	0.0	0.0	2.5	1.6	1.9	1.7	
Kurtosis	-0.6	-0.1	-0.5	-0.1	2.6	0.0	-0.45	-1.24	-1.28	-0.67	-1.06	-0.85	4.70	-1.79	1.00	0.09	-0.40	4.65	4.95	3.55	#DIV/0!	#DIV/0!	-1.16	-0.62	-0.44	-0.61	
Skewness	0.21	-0.47	-0.16	0.03	1.80	1.20	-0.10	-0.24	0.36	0.63	0.35	0.15	1.69	-0.08	1.05	0.70	0.38	1.91	1.99	0.56	#DIV/0!	#DIV/0!	0.56	0.26	0.64	0.49	
Range	12.0	12.0	9.0	12.0	2.0	3.0	74	47	4	6	4	3	9	7	8	10	5	9	14	13	0	0	4	4	4	4	
Minimum	9.0	6.5	9.0	6.5	2.0	2	50	51	0	0	0	0	4	3	1	1	0	0	1	0	0	0	0	0	1	2	
Maximum	21.0	18.5	18.0	18.5	4.0	5	124	98	4	6	4	3	13	10	9	11	5	9	15	13	0	0	4	4	5	6	
Confidence Level(95.0%)	1.77	1.51	1.90	2.27	0.45	0.74	15.16	10.69	1.05	1.42	1.00	0.70	1.56	1.76	1.56	2.19	1.06	1.62	2.51	2.06	0.00	0.00	1.06	0.85	0.91	0.86	
Observations	18	18	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Pearson Correlation	0.79		0.89		0.82		0.37		0.19		0.35		0.38		-0.22		0.74		0.79		#DIV/0!		0.28		0.43		
Hypothesized Mean Difference	0		0		0		0		0		0		0		0		0		0		0		0		0		
df	17		10		10		10		10		10		10		10		10		10		10		10		10		
α	0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		
t Stat	2.54		1.54		-1.79		1.22		-0.63		0.61		0.76		-1.03		-1.30		-1.19		#DIV/0!		-0.35		-2.97		
P(T<=t) one-tail	0.010		0.078		0.052		0.125		0.270		0.279		0.232		0.165		0.112		0.130		#DIV/0!		0.367		0.007		
t Critical one-tail	1.74		1.81		1.81		1.81		1.81		1.81		1.81		1.81		1.81		1.81		#DIV/0!		1.81		1.81		
P(T<=t) two-tail	0.021		0.156		0.104		0.250		0.541		0.557		0.463		0.329		0.224		0.260		#DIV/0!		0.733		0.014		
t Critical two-tail	2.11		2.23		2.23		2.23		2.23		2.23		2.23		2.23		2.23		2.23		#DIV/0!		2.23		2.23		

Appendix Table 25. Summary of Tows 81-100 F/V Diligence-2007-2

Diligence-2007-2

Tows 82-100: Holes Cut in Twine Top on Experimental Dredge

Species	Scallop Bushels (all good tows)		Hop Bushels(obs tows)		Trash Bushels		Skates		Barndoor		Winter Skate		Monk		Yellowtail Fid.		Sand Dab		Winter Fid.		Grey Sole		Summer Fid.		Fourspot Fid.		
	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	
Total Count	222.0	216.0	120.0	123.5	21.5	33.0	668	863	18	33	12	17	61	92	28	48	16	26	33	59	0	0	2	17	23	23	
% Difference in Count	2.8%		-2.8%		-34.8%		-22.6%		-45.5%		-29.4%		-33.7%		-41.7%		-38.5%		-44.1%		#DIV/0!		-88.2%		0.0%		
Fish Count/Scallop Bushel Catch Ratio					0.06	0.11	2.02	2.97	0.05	0.11	0.04	0.06	0.18	0.32	0.08	0.17	0.05	0.09	0.10	0.20	0.00	0.00	0.01	0.06	0.07	0.08	
% Difference in Catch Ratio					-43%		-32%		-52%		-38%		-42%		-49%		-46%		-51%		#DIV/0!		-90%		-12%		
Mean	13.9	13.5	12.0	12.4	2.2	3.3	67	86	2	3	1	2	6	9	3	5	2	3	3	6	0	0	0	2	2	2	
Standard Error	1.3	1.2	1.6	1.6	0.3	0.3	9.9	14.2	0.8	1.1	0.6	0.4	1.4	2.0	1.0	1.3	0.6	1.3	1.1	1.8	0.0	0.0	0.2	0.7	0.7	0.3	
Median	14.0	13.3	13.0	12.8	2.0	3.0	69.5	78.5	1	2	1	2	6	6.5	2	2.5	1	0.5	2.5	5	0	0	0	1	2	2.5	
Mode	14.0	12.0	#N/A	#N/A	2.0	3.0	#N/A	36	0	1	0	2	13	4	2	2	0	0	3	6	0	0	0	0	2	3	
Standard Deviation	5.3	4.9	5.0	5.0	1.0	0.9	31.2	44.8	2.4	3.4	1.8	1.3	4.4	6.5	3.3	4.2	2.0	4.2	3.4	5.8	0.0	0.0	0.6	2.3	2.3	1.1	
Sample Variance	27.9	23.9	25.3	25.4	1.0	0.9	970.6	2003.6	5.7	11.6	3.3	1.6	19.2	41.7	10.8	18.0	4.0	17.6	11.6	33.2	0.0	0.0	0.4	5.1	5.1	1.1	
Kurtosis	0.2	0.9	-0.7	0.9	0.4	-0.3	0.24	-1.36	0.14	1.91	6.55	-0.07	-0.67	-0.73	4.37	-1.11	1.46	4.17	2.14	6.17	#DIV/0!	#DIV/0!	10.00	2.74	4.94	-1.24	
Skewness	-0.20	0.15	-0.42	-0.17	0.21	0.23	0.36	0.43	1.20	1.48	2.43	0.28	0.53	0.80	1.97	1.35	1.41	2.02	1.48	2.31	#DIV/0!	#DIV/0!	3.16	1.69	1.91	-0.04	
Range	21.0	20.0	15.5	18.5	3.5	3.0	105	120	6	11	6	4	12	19	11	13	6	13	11	20	0	0	2	7	8	3	
Minimum	3.0	3.5	3.0	3	0.5	2	22	36	0	0	0	0	1	2	0	1	0	0	0	1	0	0	0	0	0	1	
Maximum	24.0	23.5	18.5	21.5	4.0	5	127	156	6	11	6	4	13	21	11	14	6	13	11	21	0	0	2	7	8	4	
Confidence Level(95.0%)	2.81	2.61	3.60	3.61	0.72	0.68	22.29	32.02	1.71	2.43	1.30	0.90	3.14	4.62	2.36	3.03	1.44	3.00	2.43	4.12	0.00	0.00	0.45	1.62	1.62	0.76	
Observations	16	16	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Pearson Correlation	0.92		0.92		0.59		0.74		0.72		0.23		0.74		-0.07		0.48		0.84		#DIV/0!		0.82		0.00		
Hypothesized Mean Difference	0		0		0		0		0		0		0		0		0		0		0		0		0		
df	15		9		9		9		9		9		9		9		9		9		9		9		9		
α	0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		
t Stat	0.73		-0.55		-4.12		-2.04		-2.00		-0.81		-2.24		-1.14		-0.86		-2.39		#DIV/0!		-2.67		0.00		
P(T<=t) one-tail	0.239		0.297		0.001		0.036		0.038		0.220		0.026		0.142		0.206		0.020		#DIV/0!		0.013		0.500		
t Critical one-tail	1.75		1.83		1.83		1.83		1.83		1.83		1.83		1.83		1.83		1.83		#DIV/0!		1.83		1.83		
P(T<=t) two-tail	0.478		0.594		0.003		0.072		0.076		0.440		0.052		0.285		0.413		0.040		#DIV/0!		0.026		1.000		
t Critical two-tail	2.13		2.26		2.26		2.26		2.26		2.26		2.26		2.26		2.26		2.26		#DIV/0!		2.26		2.26		

Appendix Table 26. Summary of All Tows F/V Diligence-2007-2

Diligence-2007-2
All Good Tows

Species	Scallop Bushels (all good tows)		Scallop Bushels(obs tows)		Trash Bushels		Skates		Barndoor		Winter Skate		Monk		Yellowtail Fl.		Sand Dab		Winter Fl.		Grey Sole		Summer Fl.		Fourspot Fl.		
Dredge	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control	
Total Count	1406.2	1298.5	779.0	729.5	132.5	155.0	3906	4023	328	344	106	85	687	728	218	292	46	82	231	345	32	40	38	64	263	311	
% Difference in Count	8.3%		6.8%		-14.5%		-2.9%		-4.7%		24.7%		-5.6%		-25.3%		-43.9%		-33.0%		-20.0%		-40.6%		-15.4%		
Fish Count/Scallop Bushel Catch Ratio					0.40	0.53	11.80	13.85	0.99	1.18	0.32	0.29	2.08	2.51	0.66	1.01	0.14	0.28	0.70	1.19	0.10	0.14	0.11	0.22	0.79	1.07	
% Difference in Catch Ratio					-25%		-15%		-16%		9%		-17%		-34%		-51%		-41%		-30%		-48%		-26%		
Mean	15.1	14.0	14.4	13.5	2.5	2.9	72	75	6	6	2	2	13	13	4	5	1	2	4	6	1	1	1	1	5	6	
Standard Error	0.5	0.4	0.6	0.5	0.2	0.2	5.9	5.9	0.8	0.8	0.3	0.2	1.0	1.0	0.5	0.7	0.2	0.4	0.4	0.6	0.2	0.2	0.1	0.2	0.6	0.6	
Median	14.5	13.5	14.5	13.8	2.0	3.0	72.5	72	5	4	1	1	13	13.5	3	4.5	0	0	3	6	0	0	0	1	3.5	4	
Mode	13.0	13.0	11.0	10.0	2.0	2.0	117	46	0	1	0	0	7	20	2	5	0	0	3	6	0	0	0	0	1	3	
Standard Deviation	5.2	4.1	4.7	3.9	1.2	1.4	43.2	43.2	5.8	6.2	2.1	1.4	7.3	7.1	3.9	5.3	1.4	2.6	3.3	4.6	1.5	1.7	1.1	1.5	4.4	4.1	
Sample Variance	26.6	17.0	22.1	14.8	1.5	2.0	1869.1	1863.6	33.9	38.7	4.5	2.1	53.8	50.7	14.9	27.6	2.1	6.9	10.9	21.6	2.3	2.9	1.2	2.4	19.5	16.4	
Kurtosis	2.6	0.1	0.2	-0.1	0.8	0.6	-0.68	-1.10	-0.54	0.26	3.46	0.13	-1.21	-0.62	12.91	14.09	3.05	6.79	1.28	3.72	10.65	11.33	1.61	3.91	2.60	0.08	
Skewness	0.83	0.10	0.15	-0.28	0.13	0.11	0.37	0.29	0.79	1.04	1.60	0.72	0.19	0.30	2.96	3.17	1.86	2.41	1.18	1.78	3.29	3.17	1.53	1.82	1.59	1.04	
Range	34.0	21.5	23.0	18.5	6.0	7.0	167	145	20	24	10	6	26	29	24	33	6	13	15	22	7	9	4	7	20	15	
Minimum	3.0	3.5	3.0	3	0.0	0	11	11	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	1	
Maximum	37.0	25	26.0	21.5	6.0	7	178	156	20	24	10	6	27	31	24	33	6	13	15	22	7	9	4	7	20	16	
Confidence Level(95.0%)	1.06	0.85	1.28	1.05	0.33	0.39	11.80	11.78	1.59	1.70	0.58	0.39	2.00	1.94	1.05	1.43	0.39	0.72	0.90	1.27	0.41	0.47	0.30	0.42	1.21	1.11	
Observations	93	93	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54
Pearson Correlation	0.86		0.89		0.83		0.86		0.81		0.23		0.71		0.69		0.60		0.63		0.67		0.46		0.71		
Hypothesized Mean Difference	0		0		0		0		0		0		0		0		0		0		0		0		0		
df	92		53		53		53		53		53		53		53		53		53		53		53		53		
α	0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		
t Stat	4.26		3.17		-3.83		-0.69		-0.58		1.26		-1.01		-2.63		-2.33		-4.27		-0.82		-2.48		-2.00		
P(T<=t) one-tail	0.000		0.001		0.000		0.246		0.282		0.106		0.158		0.006		0.012		0.000		0.207		0.008		0.025		
t Critical one-tail	1.66		1.67		1.67		1.67		1.67		1.67		1.67		1.67		1.67		1.67		1.67		1.67		1.67		
P(T<=t) two-tail	0.000		0.003		0.000		0.493		0.565		0.212		0.315		0.011		0.024		0.000		0.414		0.016		0.051		
t Critical two-tail	1.99		2.01		2.01		2.01		2.01		2.01		2.01		2.01		2.01		2.01		2.01		2.01		2.01		

Appendix Table 27. Summary of Tows 1-95 Celtic-2007-6

Celtic-2007-6

Tow 1-95: Dredge A = experimental dredge WITH turtle guards, Dredge B = experimental dredge WITHOUT turtle guards

Species	Scallop Bushels (all good tows)		Scallop Bushels (obs tows)		Skates		Black Sea Bass		Sand Dab		Fluke		Scup		Four Spot		Sea Robin		Cleanose Skate		Red Hake		Winter Flid.	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Total Count	877.5	860.5	614.5	594.0	1436.0	1240.0	2	6	14	9	72	72	3	4	12	9	118	98	108	108	1	2	0	3
% Difference in Count	2.0%		3.5%		15.8%		-66.7%		55.6%		0.0%		-25.0%		33.3%		20.4%		0.0%		-50.0%		-100.0%	
Fish Count/Scallop Bushel Catch Ratio					2.34	2.09	0.00	0.01	0.02	0.02	0.12	0.12	0.00	0.01	0.02	0.02	0.19	0.16	0.18	0.18	0.00	0.00	0.00	0.01
% Difference in Catch Ratio					12%		-68%		50%		-3%		-28%		29%		16%		-3%		-52%		-100%	
Mean	12.7	12.5	12.8	12.4	29.9	25.8	0	0	0	0	2	2	0	0	0	0	2	2	2	2	0	0	0	0
Standard Error	0.6	0.5	0.7	0.5	2.1	2.1	0.0	0.0	0.1	0.1	0.2	0.2	0.0	0.1	0.1	0.1	0.4	0.3	0.3	0.4	0.0	0.0	0.0	0.0
Median	12.0	12.0	12.0	12.0	32.0	23.0	0	0	0	0	1	1	0	0	0	0	2	1	2	2	0	0	0	0
Mode	11.0	12.0	9.5	12.0	13.0	15.0	0	0	0	0	0	1	0	0	0	0	0	0	1	2	0	0	0	0
Standard Deviation	5.3	4.2	5.0	3.8	14.5	14.4	0.2	0.3	0.5	0.4	1.5	1.6	0.2	0.3	0.6	0.5	2.6	2.2	2.3	2.5	0.1	0.2	0.0	0.2
Sample Variance	28.6	17.4	25.5	14.2	209.9	208.6	0.0	0.1	0.3	0.2	2.2	2.6	0.1	0.1	0.3	0.3	6.7	4.8	5.2	6.1	0.0	0.0	0.0	0.1
Kurtosis	4.0	1.7	7.7	0.3	-0.8	0.7	21.32	3.63	1.23	0.76	0.19	5.55	12.45	21.59	11.08	16.46	-0.28	0.11	3.42	3.25	48.00	21.32	#DIV/0!	12.45
Skewness	1.28	0.54	2.07	0.41	0.19	0.87	4.74	2.34	1.46	1.65	0.94	1.99	3.73	4.54	2.96	3.71	0.90	0.96	1.78	1.80	6.93	4.74	#DIV/0!	3.73
Range	33.5	25.0	30.5	18.0	56.0	68.0	1	1	2	1	5	8	1	2	3	3	9	8	10	10	1	1	0	1
Minimum	2.0	2	5.0	5	6.0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	35.5	27	35.5	23	62.0	72	1	1	2	1	5	8	1	2	3	3	9	8	10	10	1	1	1	1
Confidence Level(95.0%)	1.28	1.00	1.47	1.10	4.21	4.19	0.06	0.10	0.15	0.11	0.43	0.46	0.07	0.10	0.16	0.15	0.75	0.63	0.66	0.72	0.04	0.06	0.00	0.07
Observations	95	95	48		48		48		48		48		48		48		48		48		48		48	
Pearson Correlation	0.78		0.67		0.79		0.24		-0.07		0.35		-0.06		0.55		0.59		0.52		-0.03		#DIV/0!	
Hypothesized Mean Difference	0		0		0		0		0		0		0		0		0		0		0		0	
α	0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05	
P(T<=t) two-tail	0.728		0.436		0.004		0.103		0.280		1.000		0.743		0.411		0.192		1.000		0.569		0.083	

Appendix Table 28. Summary of Tows 96-108 Celtic-2007-6

Celtic-2007-6
 Tows 96-108: Dredge A = experimental dredge WITH turtle guards and frame chains, Dredge B = experimental dredge WITHOUT turtle guards and *frame chains removed*

Species	Scallop Bushels (all good tows)		Scallop Bushels (obs tows)		Skates		Black Sea Bass		Sand Dab		Fluke		Scup		Four Spot		Sea Robin		Cleanose Skate		Red Hake		Winter Fid.	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Total Count	174.5	201.0	164.5	188.0	863.0	1117.0	4	2	4	9	52	79	0	2	0	0	50	56	91	78	0	0	0	0
% Difference in Count	-13.2%		-12.5%		-22.7%		100.0%		-55.6%		-34.2%		-100.0%		#DIV/0!		-10.7%		16.7%		#DIV/0!		#DIV/0!	
Fish Count/Scallop Bushel Catch Ratio					1.40	1.88	0.01	0.00	0.01	0.02	0.08	0.13	0.00	0.00	0.00	0.00	0.08	0.09	0.15	0.13	0.00	0.00	0.00	0.00
% Difference in Catch Ratio					-25%		93%		-57%		-36%		-100%		#DIV/0!		-14%		13%		#DIV/0!		#DIV/0!	
Mean	13.4	15.5	13.7	15.7	71.9	93.1	0	0	0	1	4	7	0	0	0	0	4	5	8	7	0	0	0	0
Standard Error	0.6	0.6	0.6	0.6	7.9	6.9	0.2	0.1	0.2	0.2	0.8	0.8	0.0	0.1	0.0	0.0	1.2	1.4	1.0	1.0	0.0	0.0	0.0	0.0
Median	13.0	16.0	13.5	16.0	70.0	86.0	0	0	0	1	4.5	5.5	0	0	0	0	3.5	3.5	7	6.5	0	0	0	0
Mode	13.0	16.0	13.0	16.0	#NA	85.0	0	0	0	1	7	9	0	0	0	0	3	0	6	7	0	0	0	0
Standard Deviation	2.1	2.2	1.9	2.2	27.5	24.0	0.7	0.4	0.7	0.6	2.8	2.9	0.0	0.4	0.0	0.0	4.3	5.0	3.6	3.4	0.0	0.0	0.0	0.0
Sample Variance	4.5	4.8	3.7	4.7	755.7	575.9	0.4	0.2	0.4	0.4	7.7	8.4	0.0	0.2	0.0	0.0	18.5	24.6	13.2	11.4	0.0	0.0	0.0	0.0
Kurtosis	-1.0	-0.4	-1.1	0.4	2.0	-0.3	3.17	2.64	3.17	-0.09	-1.16	-0.96	#DIV/0!	2.64	#DIV/0!	#DIV/0!	5.41	1.13	-1.53	3.13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Skewness	0.10	-0.69	0.23	-0.98	0.79	0.32	1.93	2.06	1.93	0.17	-0.35	0.42	#DIV/0!	2.06	#DIV/0!	#DIV/0!	1.98	1.19	0.99	1.36	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Range	7.0	7.0	6.0	7.0	104.0	80.0	2	1	2	2	8	9	0	1	0	0	16	16	13	13	0	0	0	0
Minimum	10.0	11	11.0	11	32.0	53	0	0	0	0	0	3	0	0	0	0	0	0	3	2	0	0	0	0
Maximum	17.0	18	17.0	18	136.0	133	2	1	2	2	8	12	0	1	0	0	16	16	16	15	0	0	0	0
Confidence Level(95.0%)	1.28	1.33	1.22	1.37	17.47	15.25	0.41	0.25	0.41	0.39	1.76	1.85	0.00	0.25	0.00	0.00	2.73	3.15	2.31	2.14	0.00	0.00	0.00	0.00
Observations	13	13	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Pearson Correlation	0.33		0.20		0.77		0.48		0.22		0.27		#DIV/0!		#DIV/0!		0.83		0.07		#DIV/0!		#DIV/0!	
Hypothesized Mean Difference	0		0		0		0		0		0		0		0		0		0		0		0	
α	0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05	
P(T<t) two-tail	0.012		0.023		0.002		0.339		0.096		0.045		0.166		#DIV/0!		0.546		0.449		#DIV/0!		#DIV/0!	

Appendix Table 29. Summary of All Tows Celtic-2007-6

Celtic-2007-6
All Good Tows

Species	Scallop Bushels (all good tows)		Scallop Bushels (obs tows)		Skates		Black Sea Bass		Sand Dab		Fluke		Scup		Four Spot		Sea Robin		Cleanshoe Skate		Red Hake		Winter Flid.	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Total Count	1052.0	1061.5	779.0	782.0	2299.0	2357.0	6	8	18	18	124	151	3	6	12	9	168	154	199	186	1	2	0	3
% Difference in Count	-0.9%		-0.4%		-2.5%		-25.0%		0.0%		-17.9%		-50.0%		33.3%		9.1%		7.0%		-50.0%		-100.0%	
Fish Count/Scallop Bushel Catch Ratio					3.74	3.97	0.01	0.01	0.03	0.03	0.20	0.25	0.00	0.01	0.02	0.02	0.27	0.26	0.32	0.31	0.00	0.00	0.00	0.01
% Difference in Catch Ratio					-6%		-28%		-3%		-21%		-52%		29%		5%		3%		-52%		-100%	
Mean	12.8	12.9	13.0	13.0	38.3	39.3	0	0	0	0	2	3	0	0	0	0	3	3	3	3	0	0	0	0
Standard Error	0.5	0.4	0.6	0.5	3.1	4.1	0.0	0.0	0.1	0.1	0.3	0.4	0.0	0.0	0.1	0.1	0.4	0.4	0.4	0.4	0.0	0.0	0.0	0.0
Median	12.0	12.5	12.0	12.0	33.5	28.0	0	0	0	0	2	2	0	0	0	0	2	1	2	2	0	0	0	0
Mode	12.0	12.0	12.0	12.0	32.0	15.0	0	0	0	0	0	1	0	0	0	0	0	0	1	2	0	0	0	0
Standard Deviation	5.0	4.1	4.6	3.7	24.4	31.8	0.4	0.3	0.5	0.5	2.1	2.8	0.2	0.4	0.5	0.5	3.0	3.1	3.3	3.1	0.1	0.2	0.0	0.2
Sample Variance	24.7	16.5	21.1	14.0	595.1	1009.4	0.1	0.1	0.3	0.2	4.5	7.8	0.0	0.1	0.3	0.2	9.3	9.5	11.2	9.9	0.0	0.0	0.0	0.0
Kurtosis	4.6	1.3	8.8	-0.2	3.3	1.3	15.52	3.00	1.68	0.68	0.54	2.09	16.49	15.52	14.35	21.08	4.57	5.36	2.58	2.52	60.00	27.36	#DIV/0!	16.49
Skewness	1.27	0.27	2.06	0.06	1.44	1.39	3.84	2.21	1.58	1.32	1.11	1.59	4.24	3.84	3.37	4.20	1.67	1.94	1.56	1.51	7.75	5.33	#DIV/0!	4.24
Range	33.5	25.0	30.5	18.0	130.0	129.0	2	1	2	2	8	12	1	2	3	3	16	16	16	15	1	1	0	1
Minimum	2.0	2	5.0	5	6.0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	35.5	27	35.5	23	136.0	133	2	1	2	2	8	12	1	2	3	3	16	16	16	15	1	1	0	1
Confidence Level(95.0%)	1.09	0.89	1.19	0.97	6.30	8.21	0.09	0.09	0.14	0.13	0.55	0.72	0.06	0.09	0.13	0.12	0.79	0.80	0.86	0.81	0.03	0.05	0.00	0.06
Observations	82	82	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Pearson Correlation	0.75		1.00		0.99		0.62		0.88		0.97		0.69		0.94		0.99		0.98		0.56		#DIV/0!	
Hypothesized Mean Difference	0		0		0		0		0		0		0		0		0		0		0		0	
α	0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05	
P(T<=t) two-tail	0.752		0.620		0.550		0.242		0.505		0.142		0.251		0.203		0.208		0.572		0.321		0.083	

Appendix Table 30. Summary of Tows 1-72 Westport-2007-2

Westport-2007-2
Tows 1-72: Dredge A = experimental dredge WITH turtle guards and Celtic's bag configuration, Dredge B = experimental dredge WITHOUT turtle guards and Westport's bag configuration

Species	Scallop Bushels (all good tows)		Scallop Bushels (obs tows)		Skates		Monk		Black Sea Bass		Sand Dab		Fluke		Scup		Fourspot		Sea Robin		Clearnose Skate	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Total Count	1055.5	950.5	648.0	611.0	2349.0	2106.0	46	35	2	8	7	3	132	92	2	7	17	43	33	65	100	80
% Difference in Count	11.0%		6.1%		11.5%		31.4%		-75.0%		133.3%		43.5%		-71.4%		-60.5%		-49.2%		25.0%	
Fish Count/Scallop Bushel Catch Ratio					3.63	3.45	0.07	0.06	0.00	0.01	0.01	0.00	0.20	0.15	0.00	0.01	0.03	0.07	0.05	0.11	0.15	0.13
% Difference in Catch Ratio					5%		24%		-76%		120%		35%		-73%		-63%		-52%		18%	
Mean	15.6	14.0	14.7	13.9	53.4	47.9	1	1	0	0	0	0	3	2	0	0	0	1	1	1	2	2
Standard Error	0.7	0.8	1.0	1.0	5.7	5.3	0.2	0.2	0.0	0.1	0.1	0.1	0.4	0.3	0.0	0.1	0.1	0.2	0.2	0.3	0.4	0.3
Median	14.0	12.0	13.5	12.3	45.0	38.0	0	0	0	0	0	0	3	1	0	0	0	1	0	1	1	1
Mode	13.0	12.0	12.0	12.0	40.0	16.0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Standard Deviation	5.9	6.4	6.4	6.7	37.5	35.1	1.6	1.5	0.2	0.5	0.5	0.3	2.9	2.3	0.2	0.8	0.7	1.1	1.2	1.9	2.9	2.3
Sample Variance	34.8	41.6	40.9	44.5	1408.9	1230.9	2.5	2.2	0.0	0.2	0.2	0.1	8.6	5.3	0.0	0.6	0.4	1.3	1.4	3.5	8.2	5.4
Kurtosis	1.7	0.2	1.5	0.5	2.7	0.5	1.85	7.23	19.31	7.31	9.17	28.35	6.38	4.22	19.31	37.37	1.01	0.72	4.13	2.37	3.00	0.79
Skewness	1.01	0.79	0.79	0.92	1.55	1.01	1.62	2.57	4.52	2.81	3.12	5.24	2.16	1.85	4.52	5.97	1.48	1.16	2.00	1.66	1.77	1.33
Range	30.0	29.0	34.0	29.0	167.0	146.0	6	7	1	2	2	2	15	11	1	5	2	4	5	7	12	8
Minimum	6.0	4	2.0	4	6.0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	36.0	33	36.0	33	173.0	147	6	7	1	2	2	2	15	11	1	5	2	4	5	7	12	8
Observations	67.00	67.00	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44
Confidence Level(95.0%)			1.95	2.03	11.41	10.67	0.48	0.45	0.06	0.15	0.15	0.10	0.89	0.70	0.06	0.24	0.20	0.34	0.35	0.57	0.87	0.70
Pearson Correlation	0.77		0.78		0.87		0.66		-0.08		0.08		0.67		0.10		-0.05		0.23		0.63	
Hypothesized Mean Difference	0		0		0		0		0		0		0		0		0		0		0	
α	0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05	
P(T<=t) two-tail	0.004		0.208		0.056		0.195		0.110		0.290		0.009		0.342		0.005		0.018		0.192	

Appendix Table 31. Summary of Tows 73-94 Westport-2007-2

Westport-2007-2
 Tows 73-94: Dredge A = experimental dredge WITH turtle guards and Celtic's bag configuration, Dredge B = experimental dredge WITHOUT turtle guards and Westport's bag configuration and *frame chains removed*

Species	Scallop Bushels (all good tows)		Scallop Bushels (obs tows)		Skates		Monk		Black Sea Bass		Sand Dab		Fluke		Scup		Fourspot		Sea Robin		Clearnose Skate	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Total Count	342.0	414.0	214.0	253.0	476.0	808.0	26	23	0	0	1	0	24	36	0	0	3	15	7	33	7	11
% Difference in Count	-17.4%		-15.4%		-41.1%		13.0%		#DIV/0!		#DIV/0!		-33.3%		#DIV/0!		-80.0%		-78.8%		-36.4%	
Fish Count/Scallop Bushel Catch Ratio					2.22	3.19	0.12	0.09	0.00	0.00	0.00	0.00	0.11	0.14	0.00	0.00	0.01	0.06	0.03	0.13	0.03	0.04
% Difference in Catch Ratio					-30%		34%		#DIV/0!		#DIV/0!		-21%		#DIV/0!		-76%		-75%		-25%	
Mean	16.3	19.7	16.5	19.5	36.6	62.2	2	2	0	0	0	0	2	3	0	0	0	1	3	1	1	0
Standard Error	1.6	1.5	2.1	2.0	8.8	12.8	0.5	0.3	0.0	0.0	0.1	0.0	0.5	0.6	0.0	0.0	0.1	0.3	0.5	0.2	0.2	0.0
Median	14.0	18.0	14.0	18.0	25.0	54.0	1	2	0	0	0	0	1	2	0	0	0	0	2	0	1	0
Mode	11.0	18.0	22.0	18.0	28.0	11.0	1	2	0	0	0	0	1	1	0	0	0	0	2	0	1	0
Standard Deviation	7.5	6.9	7.7	7.4	31.8	46.3	1.8	1.2	0.0	0.0	0.3	0.0	1.6	2.0	0.0	0.0	0.4	1.0	1.7	0.9	0.8	0.0
Sample Variance	56.3	47.0	58.8	54.4	1010.4	2142.3	3.3	1.5	0.0	0.0	0.1	0.0	2.6	4.2	0.0	0.0	0.2	0.9	2.8	0.8	0.6	0.0
Kurtosis	-1.0	-0.7	-0.5	-1.1	0.4	-0.7	4.31	-0.43	#DIV/0!	#DIV/0!	13.00	#DIV/0!	-0.57	-1.21	#DIV/0!	#DIV/0!	0.09	2.70	0.35	4.83	-1.28	#DIV/0!
Skewness	0.40	0.32	0.48	0.30	1.29	0.39	1.94	-0.11	#DIV/0!	#DIV/0!	3.61	#DIV/0!	0.84	0.44	#DIV/0!	#DIV/0!	1.45	1.83	0.75	2.05	0.31	#DIV/0!
Range	25.0	24.0	25.0	23.0	91.0	148.0	7	4	0	0	1	0	5	6	0	0	1	3	6	3	2	0
Minimum	5.0	8	5.0	9	9.0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	30.0	32	30.0	32	100.0	152	7	4	0	0	1	0	5	6	0	0	1	3	6	3	2	0
Observations	21	21	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
Confidence Level(95.0%)	3.42	3.12	4.63	4.46	19.21	27.97	1.10	0.75	0.00	0.00	0.17	0.00	0.98	1.24	0.00	0.00	0.27	0.58	1.01	0.53	0.48	0.00
Pearson Correlation	0.90		0.91		0.67		0.15		#DIV/0!		#DIV/0!		0.69		#DIV/0!		0.48		0.22		0.37	
Hypothesized Mean Difference	0		0		0		0		0		0		0		0		0		0		0	
α	0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05		0.05	
P(T<=t) two-tail	0.000		0.006		0.020		0.692		#DIV/0!		0.337		0.046		#DIV/0!		0.021		0.001		0.264	

Appendix Table 32. Summary of Tows 95-100 Westport-2007-2

Appendix 34.

F/V Celtic's Gear Configuration:

Diamonds: 14x14

Bag: 10x40

Apron: 7x40

Sides: 6x17

Skirt: 3x40

10" twine top: 8.5x60, 2:1

Sweep: 125

Two links for each ring

Dumping chain: 98 links

Belly: 12x40

Chaffing gear used on belly between every space

Appendix 35.

F/V Westport's Gear Configuration:

Diamonds: 14x14

Bag: 9x40

Apron: 13x40

Sides: 5x17,17,15,14,13

Skirt: 2x30

10" twine top: 8.5x60, 2:1

Sweep: 121

Appendix 36.

Celtic-2007-6

TRIP SUMMARY

F/V Celtic
LOA Permit Number: 410146
Date Sailed: Monday 11/5/2007
Port Sailed: New Bedford
Date Landed: Tuesday 11/13/2007
Port Landed: New Bedford
Dealer: Eastern Fisheries
9 DAS
Target RSA: 20,740 lbs.
Area: Elephant Trunk
Observers: Matt W., Tim W.
Captain: Paul D.
Mate: Tim Q.
Crew: Anthony, Joe, John, Pat, Jim
7 Days Fishing
109 Total Tows
60 Observed Tows

Trip Goal: Compare two turtle dredge designs, one with teeth and one without teeth, to see if there is a significant difference on scallop catch and fish bycatch.

Gear used:

Dredge Frame: 2 final turtle dredge frame designs. Frames were basically identical with the test feature of 1" round stock hardened steel placed flush to the cutting bar (teeth) and overlapping and extending from each strut on the frame. This was designated dredge A and was fished on the port side throughout the trip. Dredge B was the same dredge design without teeth and was fished on the starboard side throughout the trip.

Dredge A = turtle dredge WITH teeth. (port side)

Dredge B = turtle dredge WITHOUT teeth (starboard side)

Minor difference noted between the tow dredge frames include:

- Cutting bar is $\frac{1}{4}$ " above the shoe on dredge A. On dredge B the cutting bar is $\frac{1}{4}$ " below the plane of the shoe.
- The bumper plate on dredge A is curved and on dredge B it is a triangle.
- Frame width across front of wheels is 33" for dredge A and 38" on dredge B.

- Dredge A is 73" behind the wheels. Dredge B is 78" behind the wheels.
- Dredge A has 18" extensions from the frame to the bail bar. Dredge B has 14" extensions.
- Dredge A has a 22" shoe and 11" heel. Dredge B has a 20" shoe and 11" heel.
- Chains on frame B seem to be tighter than on frame A. B has 9 chain links and A has 10 chain links.

(illustrations of measurement locations are available)

Characteristics shared between the two dredges:

- Both have 2 molded 5"x16" wheels with the axis positions ~30" from the top of the gooseneck. (dredge A had cookie spacers one each side of the wheel, while dredge B had no spacers)
- Both Dredges are 15' wide across the top of the depressor plate.
- Outside bail bars on both are double bar and a single 2"x3" rectangle stock for the middle bar.
- Both have the cutting bar positioned at a 45 degree angle.
- Both measure 9' from the gooseneck to the extension.
- The single middle bar is 7'.
- 20" frame height from the heel to the top of the depressor plate.
- Both have chains between each strut.
- 8" wide spacing between struts with the chain positioned at 4" in-between struts.
- 10" between cutting bar and depressor plate.
- 8" forward face of depressor plate and 3" top of frame.
-
- 18 full windows with a 5.5" on each end.
- 4.25 inch wide double bail bars.

Dredge Bag:

Both bags used are identically set up and regularly used by the F/V Celtic. Both bags used during this trip were made of new gear.

New twine tops that measured 11 inches before use. The twine top was hung 2:1.

Other bag gear characteristics:

Diamonds: 14x14

Bag: 10x40

Apron: 7x40

Sides: 6x17

Skirt: 3x40

10" twine top: 8.5x60

Sweep: 125

Two links for each ring

Dumping chain: 98 links

Belly: 12x40

Keyhole rubber chaffing gear used on belly between every space.

6 cookies on side piece right behind frame so that frame doesn't crush bad when setting out.

No turtle chains were used during the trip.

One center rock chain and one tickler chain were used throughout trip.

Monday 11/5/07

We caught the 14:15 bridge and started steaming to fishing grounds. Rough weather was blowing against us; slowing our progress and making difficult to do anything (including sleep).

Tuesday 11/6/07

We continued steaming to fishing grounds. It took about 32 hours to reach the spot where the captain wanted to start fishing. Started fishing at 21:40. The port side had the dredge with teeth (dredge A) and the starboard had the dredge without teeth (dredge B). The starboard dredge's twine top hung up on the frame chains during the first tow, so we went to bed to get a fresh start and regular watch schedule in the morning. We plan on letting the crew load up and work at night and for us to sample tows during daylight hours (5:30 - 6:30). We would eat dinner with the crew when they got off watch in the evening. The captain or mate will record data on the bridge log throughout the trip. There are several Eastern Fisheries vessels fishing in the general area. No gear damage or changes were made during day one of fishing.

Wednesday 11/7/07

We started sampling today. Although, only two tows were sampled for fish by the end of our watch. There were two tows with twine top hang ups that were not sampled. The crew kicked over fish on two tows and there were

several "accidentally" large tows that were not sampled. There were not many fish to sample in any of the tows during the day. The larger tows had smaller scallops than the captain was looking for so we moved away from that area to more shoal water to the west. For most of the day we were fishing toward the northwest corner of the Elephant Truck Area. We were doing straight 20 to 40 minute tows in 22 fathoms of water. Catch sizes ranged from 8 to 40 bushels. The gear was not changed or damaged during our watch. There was some trouble with the twine top hanging up on either the frame chains or teeth. The crew was also having trouble getting the scallops out of the front corners of both bags. Approximately 1 bushel of scallops would get caught in each corner while the bag was being dumped. The bag would get pinched during dumping and the crew could not shake the scallops out. The dredge was lifted jerked up and down in attempt to get the scallops out of the bag, resulting in more of the scallops on deck to be crushed. The scallops in this area seem to have thinner shells and are easily crushed. The captain also commented that the scallop meat volume was ~20% less than it was in March. Although in March there were more non-marketable orange scallops. 76 bags weighing approximately 50 lbs. were put in the hold by the last watch of 11/7/07. We are well behind our target of sampling 10 tows/day; needed to reach our goal of 60 tows sampled by the end of the trip. No gear changes or damage occurred during day 2 of fishing.

Thursday 11/8/07

Today we tried to catch up with the number of tows sampled by doing shorter tows. This was somewhat of an annoyance to the crew since they had to handle gear more often. Luckily the weather was fair, allowing us to get some good sampling done. We also did a longer watch several hours into the night. There was noticeably more fish bycatch during the night tows. We got 13 tows sampled during our watch which brought us up to a total of 15. The crew kicked fish over on two tows which then could not be sampled. I spoke with the crew and it will not happen again. We are still not seeing much for fish bycatch in either dredge. Species that we have been seeing regularly include: fluke, clearnose skate, little skate, sea robin. The trash usually consists primarily of sponge and crushed scallops. Some old oyster shells are showing up in the catch (seems to be more in dredge B). We have also occasionally found small black sea bass, small scup, and sand dabs. We did approximately 20 minute long straight tows in an area to the west of where we fished yesterday. The F/V Challenge was fishing in the same area during most of the day. The captain, Charlie Quinn, is using a 13' version of the turtle dredge and a 13' standard New Bedford dredge. He is also keeping records of scallop catch from both dredges. None of our gear was changed or damaged on day 3 of fishing. 86 bags of scallops were put in the on 11/8.

Friday 11/9/07

Today is rainy and cold. Since no noticeable difference has been observed in the scallop size frequency, we limited out scallop measuring today. Since the weather is rougher, we are doing turns before hauling back. We had sampled 12 tows by the end of the day and filled 87 bags of scallops. It was noted that dredge B seemed to be shinning higher up on the frame than dredge A. It might be digging into the bottom more. There hasn't

been a readily noticeable difference in scallop catch nor bycatch in either dredge. The fishing gear was not changed or damaged during day 4 of fishing.

Saturday 11/10/07

The weather is rougher today. By the end of the day we had ~30 hours to do 25 tows to reach the target of 60 sampled tows. Tim and I broke watches so that all tows for the rest of the trip could be sampled. I stayed up for another watch and Tim got up at 0:00 to cover the night watch. The captain commented that the scallops in this area seem to have heavier shells than any other he has seen. The scallops are clean, not with the black on the shells that the thinner ones to the east had. Some of the crew has starting to get "the grip", which might be resulting from shucking the heavier shells. No gear was changed or damaged during the 5th day of fishing.

Sunday 11/11/07

We have caught up to where we need to be as far as sampling and the weather is once again fair. Since we have approximately 10 tows left and there has not been a difference in catch, I asked the crew to cut off the frame chains on dredge B. This occurred between tow 95 and 96. Dredge B was picked for the modification since it was probably closer to the final dredge design, thus would be of more interest in comparing to future tests. It was noted that dredge B had tighter chains (one less link) than dredge A. Tow 96 (the first without the frame chains on dredge B) had larger difference in scallop catch than any previous successful tow. Dredge A had 11.5 bushels and dredge B had 18 bushels. There was also more fish bycatch and trash in dredge B. This trend continued for most of the remaining tows. We were also occasionally catching puffer fish in dredge A. Other than the frame chains being cut off dredge B, there was no damage or change in the fishing gear during day 6 of fishing.

Monday 11/12/07

Steamed home

Tuesday 11/13/07

Offloaded scallops at Eastern Fisheries

Appendix 37.

Westport-2007-2

TRIP NOTES

F/V Westport
LOA Permit Number: 410249
Date Sailed: Tuesday 11/20/2007
Port Sailed: New Bedford
Date Landed: Thursday 11/29/2007
Port Landed: New Bedford
Dealer: Whaling City Seafood Auction
10 DAS
Target RSA: 20,739 lbs.
Area: Elephant Trunk
Observers: Matt W.
Captain: Eddie Welch
Mate: Nate
Crew: Foggy, Shane, Shane, Jim, Tom
8 Days Fishing
100 Total Tows
62 Observed Good Tows
4 Observed Bad Tows

Trip Goal: Compare two different dredge bag gear set up; explore possible dredge modifications for bycatch reduction; explore affects of scope and speed combination variables on catch.

Gear used:

Dredge Frame: 2 final turtle dredge frame designs. Frames were basically identical with the test feature of 1"round stock hardened steel placed flush to the cutting bar (teeth) and overlapping and extending from each strut on the frame. This was designated dredge A and was fished on the starboard side throughout the trip. Dredge B was the same dredge design without teeth and was fished on the port side throughout the trip. Both of these dredge frames were used previously on Celtic-2007-6, and were labeled the same.

Dredge A was set up with a dredge bag configuration used regularly by the F/V Westport. Dredge B was set up with a bag configuration used regularly by the F/V Celtic. Crew on the Westport set up all gear and used old gear from the Westport to match the Celtic's configuration.

Dredge A = turtle dredge frame WITH teeth. F/V Westport's bag configuration. (starboard side)

Dredge B = turtle dredge frame WITHOUT teeth. F/V Celtic's bag configuration(port side)

Dredge A's bag configuration:

All metal sections of the bag were old used gear from the F/V Westport. Gear was "loose" from use all season. There were also several hangers that were cut off during the trip.

Diamonds: 14x14
Bag: 9x40
Apron: 13x40
Sides: 5x 17,17,15,14,13
Skirt: 2x30
10" twine top: 8.5x60, 2:1
Sweep: 121 large links

One center rock chain and one tickler chain were used throughout trip.

The twine top was old, not new as dredge B's was.

Dredge B's bag configuration:

Diamonds: 14x14
Bag: 10x40
Apron: 7x40
Sides: 6x17
Skirt: 3x40
10" twine top: 8.5x60
Sweep: 125
Two links for each ring
Dumping chain: 98 links
Belly: 12x40

All metal sections of the bag were old used gear from the F/V Westport. Gear was "loose" and used all season.

Brand new twine top was used on this bag.

No cookies were used on the side of bag as on the F/V Celtic.

No turtle chains were used during the trip.

One center rock chain and one tickler chain were used throughout trip.

All exploratory gear modifications were made to this dredge frame and bag.

11/20/2007

Started Steaming at 10:15

Frame chains on dredge B were replaced after having been removed during Celtic-2007-6.

Have the GPS software logging positions, speed, heading, and effort number every 10 seconds. An average speed during each tow can be calculated after the trip. There is a temperature logger on dredge B that is polling every 16 seconds for most of trip.

After settling into a area to fish, we plan on rotating threw a set of towing variables testing the effects of speed and scope. We will tow straight in one direction at 3.8 knots and 3:1 port, 4:1 starboard. Then back down the tow path at 4.3 knots 4:1 port, 3:1 starboard. Then back up 3.8 knots 4:1 starboard, 3:1 port and back down again at 4.3 knots with 4:1 port and 3:1 starboard.

We will try to do ~1 hour tows. I will work the captains watch for the entire trip, sampling every good tow with the goal of getting at least 60 tows sampled.

11/21/2007

Started fishing at 14:00

Towing south to the same area that was fishing during Celtic-2007-6.

Fair weather (2-3 ft seas) today, but expecting a gale tomorrow.

I am logging each tow with the GPS software.

The crew has been having a hard time setting the dredges. They are not used to flaring the dredges, so there is some learning curve to be overcome. They are setting one dredge (usually the starboard) first, then setting the second. So there is a few minute time lag between each dredge being set.

We started fishing ½ way through the watch, so only a few tows were sampled. There were also a couple of bad tows that were not sampled.

The crew had a hard time dumping the port dredge. The scallops in the twine top kept sagging over the frame. (see photo) Captains says this is happening because the apron or twine top is too long. Scallops were also getting caught in the forward corners of dredge B (similar to Celtic-2007-2). Captains says this is because the sweep is too tight (too short) and causing the bag to pinch during dumping. Bag specs given by the Celtic was for 125 links in the sweep, although I remember a crew member telling me during the trip it was 127 links.

11/22/2007

Tows 11 and 12 were no good.

Dredge B doesn't seem to be fishing right. The crew did some gear work to dredge B, ("loosened the corners up a bit").

Weather has been crappy.

We are not fishing the variable routine yet. The captains wants to get dredge B fishing right, look around for scallops, and wait for the weather to calm down.

Big piles of monkey dung. Monkey dung is getting caught on both frames, which might be clogging the frame windows.

11/23/2007

Weather improving.

Scallop catch seems to be erratic.

Crew is still having a hard time dumping.

Between tow 28 and 29 the Chains were cut off the right side of dredge B's bag. This was to see if it helped making the dumping easier. In doing so it essentially created a window on the side of the bag, which was going to be one of our exploratory tests anyway. I was not immediately aware that the crew had done this. Once I found out I asked for them to cut off the chains on the other sides of dredge B as well. This was done after tow 50. So there is just one chain (the top chain) holding the side piece to the dredge frame.

Mate mentioned that the new dredge is good in that the main wire doesn't get caught up on the corner of frame while on deck as sometimes happens with the old dredge.

11/26/2007

Cut the frame chains off of dredge B between tows 72 and 73. 45 good tows had been sampled with the chains on.

Have not done the sampling routine yet and there is supposed to be bad weather tomorrow.

Mate had a tow with a load of really small seed (dust).

Captain says to use trawlex chain for the Celtic's skirt instead of rings. This will make dumping easier without reducing catch.

11/28/2007

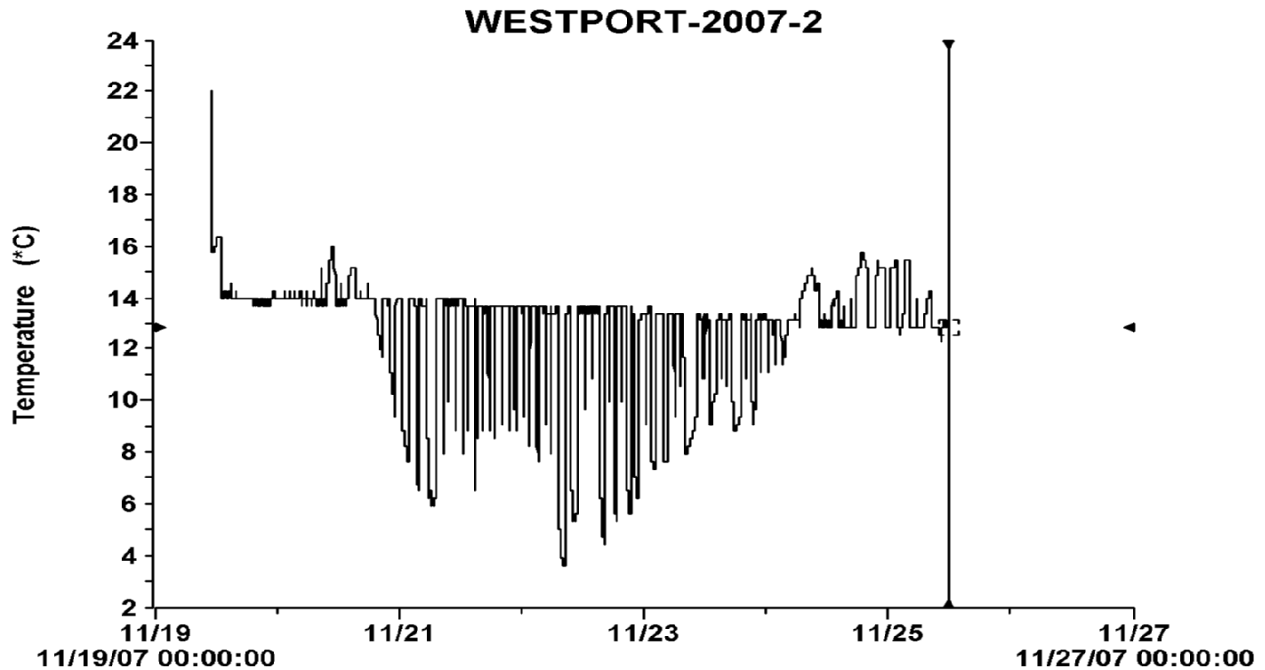
Last watch and it is really crappy out.

We put windows in the forward corners of dredge B's twine top. Captain did not want to cut the twine top (costs \$500) so we unraveled it from the chain bag and folded it back. Unraveled 3 rings across (10 meshes) and 3 rings deep.

No immediately noticeable difference in the bycatch.

We never did the towing variable test routine. Captain was not into it for this trip because of weather, new gear, new setting method, and was under pressure to get 60 tows sampled.

Appendix 38. Plot of Temperatures Taken During Westport-2007-2



Appendix 39.

Description of materials used in experimental dredge design

Cutting bar: 2" x 3" solid steel bar at 45 degree angle place in front of the pressure plate

Struts 5/8" x 3" steel plate cut 24" long with cut-outs at each end to fit and a tapered leading edge. The angle of the struts is 45 degrees.

Main frame 5/8" x 3" steel plate

Turtle chain plate 5/8" x 3" w/1" holes on 12" centers; plate welded to rear of cutting bar

Pressure plate 3/8" x 8" steel plate

Skirt attachment bar 3/4" round stock; passes through holes in struts

Main bale bar 2 1/2" round bar

Heel plate of shoe 1/2" x 3" x 11"; welded to shoe; also covers the 2 1/2 " ears at rear

Bullring: 1 1/2" round bar formed to circle of 6" I.D.

Center bar: 2" x 3" steel bar

Lifting bar: 1 1/4" round bar; attached to top of center bar